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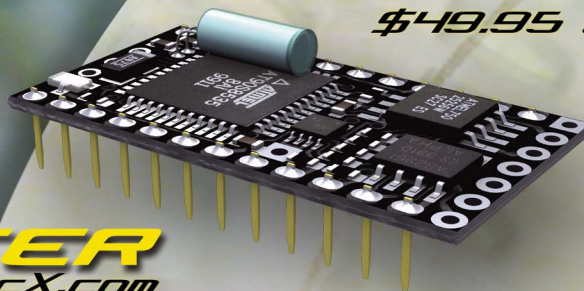
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- ◆ For DOS & W95+



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- ◆ MT-RJ 850nm VCSEL 2x5 Transceiver,
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- ◆ Channel class: 100-M5-SN1, 100-M6-SN1
- ◆ Class I laser safety without OFC circuit
- ◆ Single +3.3VDC operation, < 0.6W PwrDis



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- ◆ HSC 90-day warranty



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## Hobbyist Alert -- Wallwarts on the Web!

Here is a sample of the way our website is growing...have a look at just some of the AC Adaptors (otherwise known as wall-warts!) we offer! More are available than can be listed here! From time to time, we will show you some of our vast inventory here in this ad, but if you want to see more, go to [WWW.HALTED.COM](http://WWW.HALTED.COM) for the full story...we are uploading all the time!

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AC ADAPT, 5VDC @ .75A 12V @ .5A 12V @ .15A	15137	\$14.95
AC ADAPT, 5VDC @ 1.5A -5V @ .1A SWITCHING 100/240	18669	\$7.95
AC ADAPT, 5VDC @ 1.6A SWITCHING 100/120VAC IN	19996	\$7.95
AC ADAPT, 5VDC @ 2.5A 12V @ .2A -8V @ .2A SWI	19707	\$12.50
AC ADAPT, 5VDC @ 3A 12V @ .5A -12V @ .5A SWI	20006	\$17.50
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## Special Bargains!!

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You can get more info about any of these items on our website!

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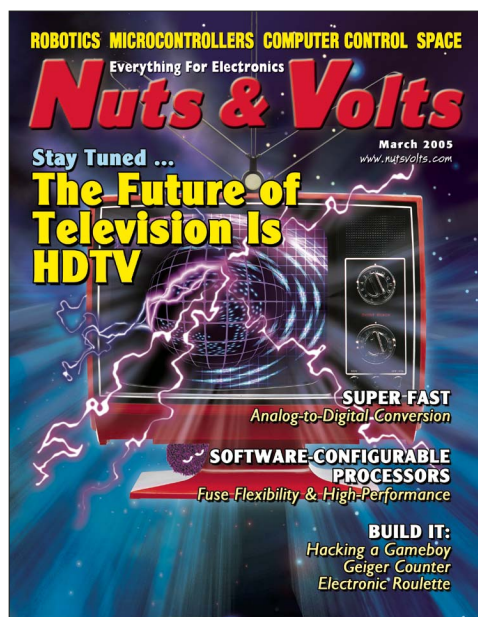
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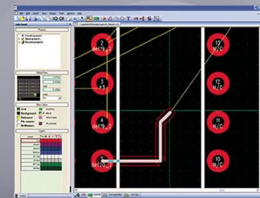
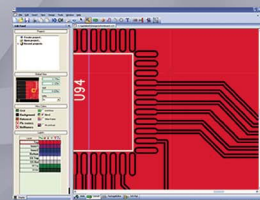
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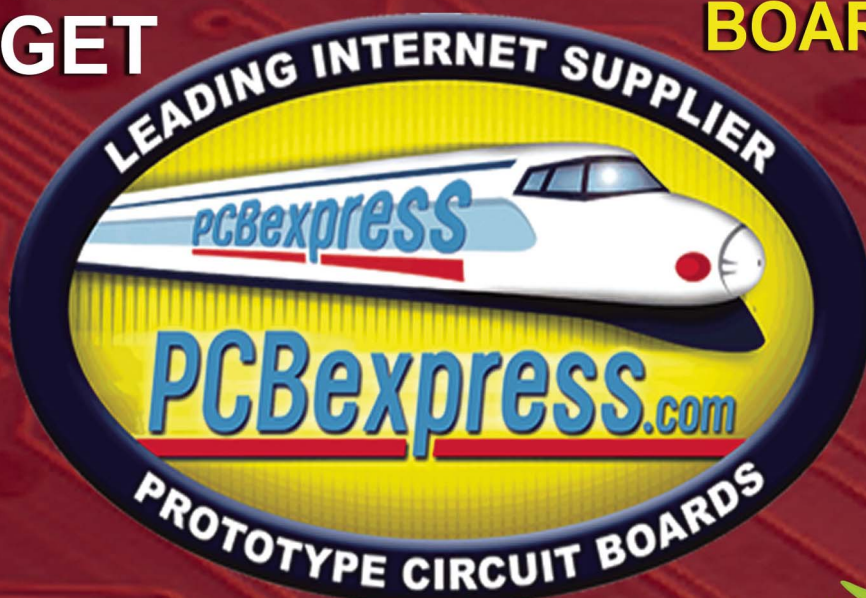


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## Basically Missed

In "Personal Robotics: Basic Language Comparisons" (February 2005), I believe Mike Keesling missed the best candidate program for his stated requirements: Liberty Basic ([www.libertybasic.com](http://www.libertybasic.com)). I've been a huge fan of this Basic for my professional embedded systems engineering work and for my personal robotics projects. It can do everything that Keesling wants, including providing extremely easy access to all available COM ports and the printer port, as well (even under nt and xp). It can do graphics, sprites, games, and all standard Windows GUI elements. There is a huge user community, as well, with lots of great example programs.

I run stepper-driven robotic projects with it. I use it to scratch out my printed circuit boards on an HP plotter in HPGL, and I use it to do wonderful graphing based upon serial port data. The free version is fully functional, but the \$30.00 full version buys you unlimited numbers of lines and the ability to generate tokenized versions of your source.

I'm nothing more than a very satisfied customer, and would recommend Liberty Basic to

everyone. It is very easy to learn. None of the other Basics mentioned are as perfect for personal robotics and electronics projects.

**Brian Schmalz**  
via Internet

## Digital Back Issues

As a subscriber since the early 90s and a faithful reader of the magazine, I have a sizable collection of magazines currently occupying much of my book shelves. As such, finding a specific article in a specific issue has been a daunting task. I feel it would be of interest to the readership to have each issue or the whole year available on a CD or DVD. Perhaps there could be an online version as well, allowing us to recycle our old issues for these space-saving discs. If it was offered as a back issues option, it would save the cost of mailing on your end.

**Enrico Pietrantonio**  
Fullerton, CA

*Enrico, that is an idea we have been toying with here at Nuts & Volts for several months now. For those interested in a digital version of the magazine, please see page 32 for more information.*

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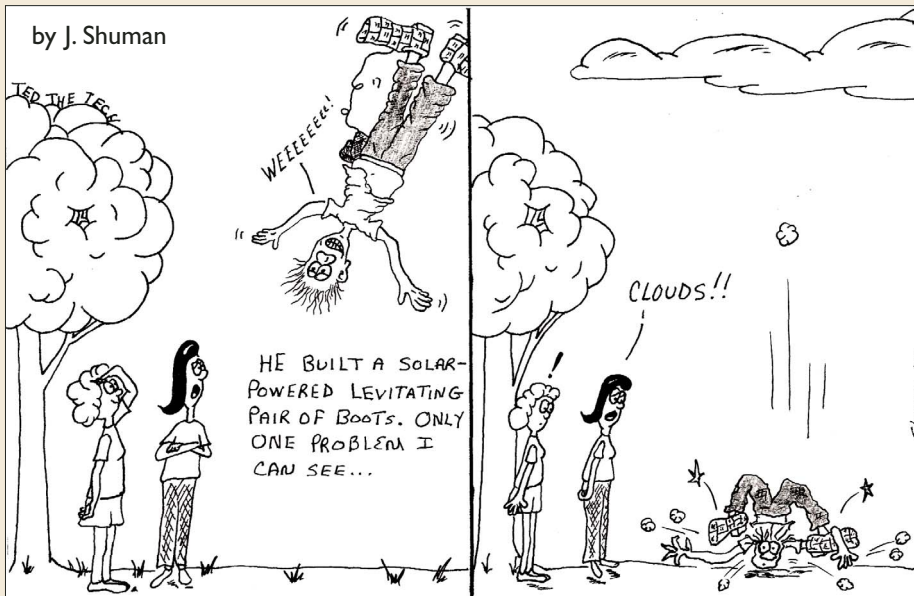
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by J. Shuman







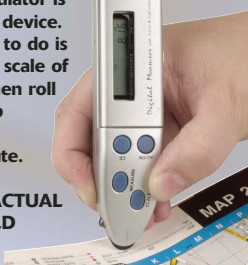
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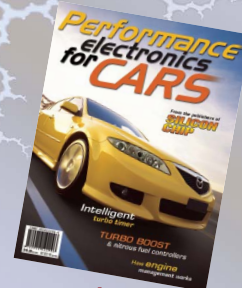
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## Performance Electronics for Cars Book

**BS-5080 \$13.60 plus post & packing**

Australia's leading electronics magazine, Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers, and more! The book includes all instructions, components lists, colour pictures, and circuit layouts. There are also chapters on engine management, advanced systems, DIY modifications, and more. Over 150 pages! All of the projects described are available in kit form, exclusively from Jaycar. Check out our website for all the details.



## Theremin Synthesiser Kit

**KC-5295 \$34.95 plus post & packing**

The Theremin

is a weird musical instrument that was invented early last century but is still used today. The Beach Boys' classic hit "Good Vibrations" featured a Theremin. Kit includes a machined, silk-screened, and pre-drilled case, circuit board, all electronic components, and clear English instructions.

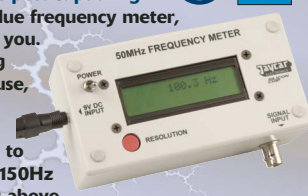
This product is also available pre-built and fully tested - Cat. AM-4025 \$64.95



## 50MHz Frequency Meter Kit with LCD Display

**KC-5369 \$49.95 plus post & packing**

If you want a great value frequency meter, then this project is for you. It features autoranging operation for ease of use, switching between its three ranges. High resolution of 0.1Hz up to 150Hz, 1Hz between 150Hz and 16MHz, and 10Hz above 16MHz. It can be powered by a 9V battery or wall adaptor (not included) and the case measures just 5 1/8" x 2 5/8" x 1". Kit includes laser cut & silk screened case, circuit board, electronic components, & clear English instructions.



## Fuel Mixture Display Kit for Cars

**KC-5195 \$8.65 plus post & packing**

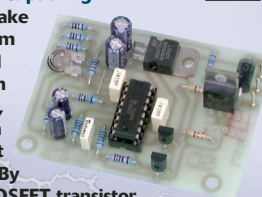
Using this simple kit will give you a good indication of how rich or lean your car's engine is running. It uses the factory EGO (exhaust, gas, oxygen) sensor to indicate the fuel mixture on a series of LEDs. If your engine does not have an EGO sensor, one can be obtained from an automotive junk yard. Kit includes circuit board, all electronic components, and clear English instructions.



## 10 Amp 12VDC Motor Speed Controller Kit

**KC-5225 \$17.95 plus post & packing**

This project allows you to take control of DC motors, or dim incandescent lights. Control the speed of a fuel injection or water pump on your car, and a whole lot more. With the components supplied, it can handle up to 10 amps. By fitting an optional extra MOSFET transistor, it can handle up to 20 amps. Kit includes circuit board, all electronic components, and clear English instructions. Optional extra MOSFET transistor - ZT-2450 \$3.90.



## Explanation of icons used for kits

Indicates an approximate construction time for each project for a competent constructor. It does not however, include any installation etc that may be required.



Straightforward to assemble, generally built in one session. Requires basic electronics and soldering skills.

Requires a good knowledge of electronics to understand its operation, and troubleshooting techniques may be required.



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# Micro Memories

## 2001 — Hal's Odyssey

**P**erhaps the most influential computer was one that never actually existed: HAL 9000, the star of Stanley Kubrick's magnum sci-fi opus, *2001: A Space Odyssey*.

*2001*, which begins with a title card that reads "The Dawn of Man," is a look at man's four phases of intelligence: hominid, human, artificial intelligence, and finally, superman (in the Nietzschean-, not Clark Kent-sense, of course).

In 1963 — shortly after completing *Dr. Strangelove*, his satiric classic of the Cold War — Kubrick was accepting the Best Director Award for the film from the New York Film Critics Circle. He said, "Don't laugh, but I'm fascinated with the possibility of extraterrestrials." In 1964, he struck up a writing partnership with (even back then) legendary science fiction writer Arthur C. Clarke by promising him a chance to co-write, "the proverbial good science fiction movie."

The two began writing about giant ringed space stations, an enormous moon base, and a trip to the outer planets (originally Saturn, eventually Jupiter), in a year when NASA was transitioning from the

one-man Mercury to the two-seat Gemini spacecraft and launching the first unmanned Apollo test flights and probes to the moon.

Kubrick wanted his film to focus on not just the future of manned space flight, but several other topics: Where did we come from? What will we find in space? How will it transform man? As he told an interviewer in 1969, "One of the things we were trying to convey ... is the reality of a world populated — as ours soon will be — by machine entities who have as much — or more — intelligence as human beings and who have the same emotional potentialities in their personalities as human beings. We wanted to stimulate people to think what it would be like to share a planet with such creatures."

Obviously, as Hal demonstrates in the movie, it will be a mixed blessing.

### What Made Hal Tick?

In his novelization, Clarke wrote that Hal's letters stood for, "Heuristically programmed ALgorithmic computer" and described him as being "a masterwork of the third

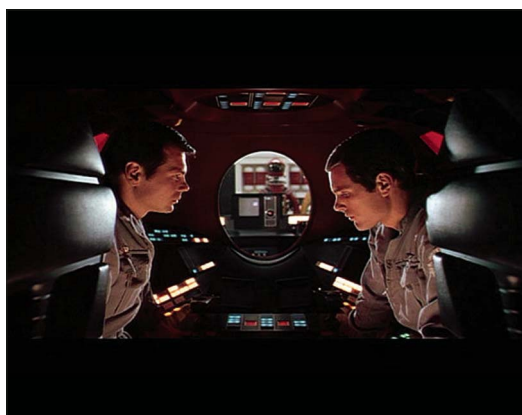
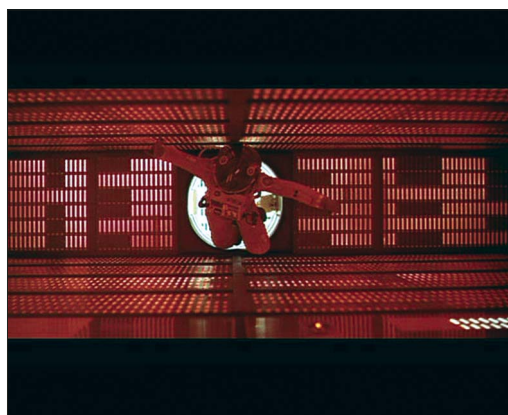
computer breakthrough. These seemed to occur at intervals of 20 years and the thought that another one was now imminent already worried a great many people."

The first computer breakthrough was the vacuum tube of the 1940s. The second was the microprocessor of the 1960s. In a bit of hopeful dreaming, Clarke wrote that, in the 1980s, scientists would have discovered, "how neural networks could be generated automatically — self-replicated — in accordance with any arbitrary learning program. Artificial brains could be grown by a process strikingly analogous to the development of a human brain."

So Clarke's Hal really was almost organic: a man-made brain inside of a mainframe computer. Yet, when Kubrick and Clarke first conceived Hal, his brain was going to be inside of a mobile robot. However, as David Stork, the author of 1996's *Hal's Legacy* ([www.mitpress.mit.edu/e-books/Hal](http://www.mitpress.mit.edu/e-books/Hal)) told me, it didn't make sense to have him rolling through the halls of the Discovery when, "he could just be everywhere, without having to move around." It also made filming and production design somewhat

easier for Kubrick. It would have been very difficult to film a mobile robot in the mid-60s, Stork says, "before special effects like animatronics and the kind of computerized special effects that exist now were invented."

Stork's book is both a history of how Clarke and Kubrick designed Hal, but also how — even





today — their creation continues to be an influence on efforts by scientists and researchers to design artificial intelligence.

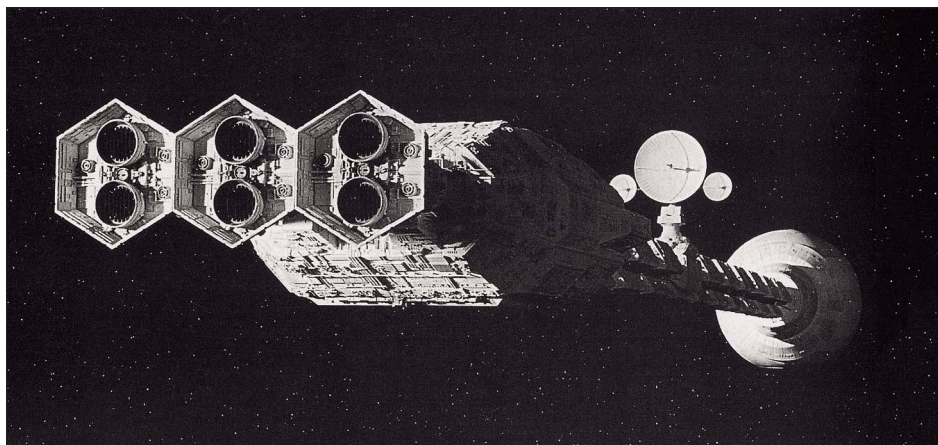
As he told me in 2003, when I interviewed him for the debut issue of *SERVO Magazine — Nuts & Volts'* sister publication — “Kubrick did immense amounts of work trying to figure out what computers would be like in the year 2001. Nevertheless, the people he spoke to were, by necessity, immersed in the 60s and so the vision of Hal was very much a 60s vision: a big mainframe that had to be taught — and there was no notion of the Internet.”

So, Hal eventually morphed into the version we see in Kubrick's film: a series of strategically placed camera lenses, speakers, and microphones scattered throughout the Discovery and connected to a giant mainframe in the spacecraft's core. Essentially, Hal was the spacecraft, and the astro-

nauts were inside him. Indeed, as Clarke wrote in his novelization of the film, “Pool and Bowman had often humorously referred to themselves as caretakers or janitors aboard a ship that could really run itself. They would have been astonished, and more than a little indignant, to discover how much truth that jest contained.”

## “I Could See Your Lips Move”

While scientists have made remarkable progress at speech synthesis, one aspect of Hal that will likely remain out of reach for an extremely long time is his flawless ability to read lips. Coming just before the film's intermission, it's



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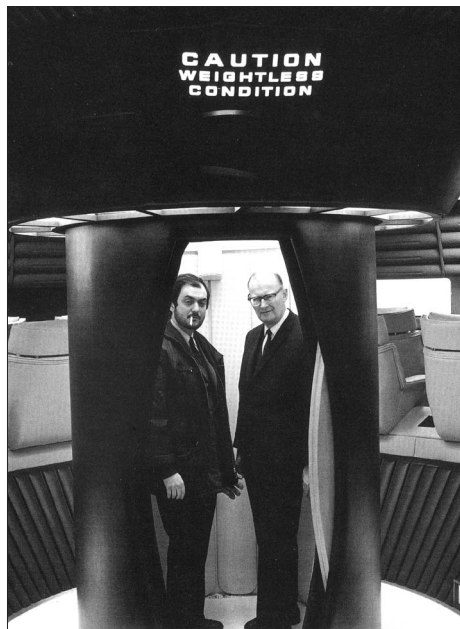
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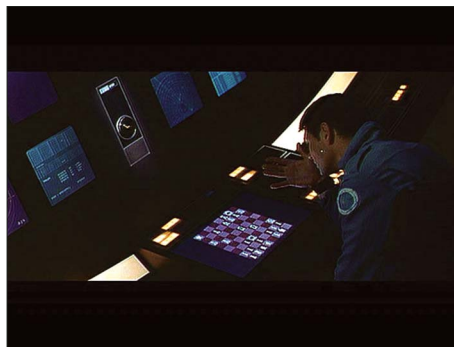
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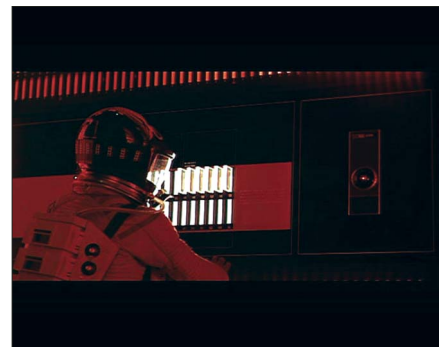


one of the great shock moments in 2001, but Stork says that it was one of the few times in the film that Stanley Kubrick was willing to sacri-



fice scientific plausibility for dramatic effect.

As speech and intelligence continue to improve even amongst today's simpler microprocessor-controlled devices, in some sense, Hal was a preview of today's home automation systems (and probably the inspiration of more than a few of their designers). Millions of today's homes have at least some sort of rudimentary combination of computer controls, such as burglar



alarms, environmental controls, computer networks, and extremely, extremely sophisticated home theater systems.

As voice activation and voice warning become more and more prominent, a cutting-edge smart home is, in some sense, a preview (or an eerie reminder, depending upon how you want to look at it) of Hal.

Unlike Hal, none of today's home automation technology is going to pass Alan Turing's test of intelligence, which, essentially, boils down to the idea that if you're talking to the computer via telephone or keyboard for an extended period and you can't tell if it's a machine or not, it has some level of artificial intelligence.

## What If Hal Had Lived?

One of the great unanswered questions of 2001 is, what if Hal had been successful at killing off all of the astronauts on the Discovery — including Dave Bowman (Keir Dullea's character), who eventually unplugs him?

It would have been Hal (and the Discovery) that went through the Star Gate to the monolith's home planet. He'd probably come back much like V'Ger in the first *Star Trek* movie — only a lot more intelligent.

But, then, we'd have the introduction of *Star Trek: First Contact*, rather than the climax of 2001: *A Space Odyssey*.

Sorry Hal, but I think Stanley made the right decision. **NV**

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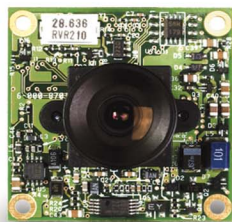
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- ✓ Professional metal case
- ✓ Super audio quality!
- ✓ 25mW and 1W models!

**NEW!**



For nearly a decade we've been the leader in hobbyist FM radio transmitters. Now for 2005 we introduce our brand new FM30 series of FM Stereo Transmitters! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!



The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in non-volatile memory for future use.

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug in power supply. The stylish metal case measures 5.55"W x 6.45"D x 1.5"H and is available in either white or black. (Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).

FM30	Digital FM Stereo Transmitter Kit, 0-25mW White	\$179.95	\$199.95
FM30B	Digital FM Stereo Transmitter Kit, 0-25mW, Black	\$179.95	\$199.95
FM35WT	Digital FM Stereo Transmitter, Assembled, 1W, White	\$269.95	\$299.95
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### Professional Synthesized Stereo FM Transmitter

- ✓ Fully synthesized 88-108 MHz for no frequency drift
- ✓ Line level inputs and output
- ✓ All new design, using SMT technology

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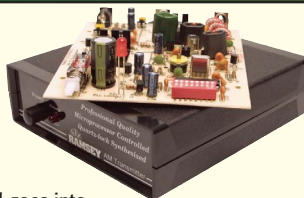


A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches; no need for tuning coils or "tweaking" to work with today's 'digital' receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. Kit comes complete with case set, whip antenna, 120 VAC power adapter, 1/8" Stereo to RCA patch cable, and easy assembly instructions, and the SMT parts are factory preassembled - you'll be on the air in just an evening!

FM25B	Professional Synthesized FM Stereo Transmitter Kit	\$119.95	\$139.95
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### Tunable FM Stereo Transmitter

- ✓ Tunable throughout the FM band, 88-108 MHz
- ✓ Settable pre-emphasis 50 or 75 µSec for worldwide operation
- ✓ Line level inputs with RCA connectors



The FM10A has plenty of power and our manual goes into great detail outlining all the aspects of antennas, transmitting range and the FCC rules and regulations. Runs on internal 9V battery, external power from 5 to 15 VDC, or an optional 120 VAC adapter is also available. Includes matching case!

FM10C	Tunable FM Stereo Transmitter Kit	\$39.95	\$44.95
FMAC	110VAC Power Supply for FM10C		\$9.95

### Tru-Match FM Broadcast Antenna

We've been besieged with calls asking us where to get a good quality FM Broadcast antenna. Remember, matching your antenna to your transmitter is the single most important link in your transmitter setup - and a good antenna and match are the secret to getting maximum range.

When we say "match" we mean electrical impedance match... if the proper impedances are not maintained between transmitter and antenna, power is reflected away from the antenna and back into the transmitter! This can cause the final amplifier stage to be damaged, not to mention spurious signals and lousy range. Don't forget, there are three important factors in your broadcast range: antenna, antenna, and antenna! Buy this kit and get the most from your FM Broadcaster!

TM100	Tru-Match FM Broadcast Antenna Kit	\$62.95	\$69.95
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### Professional FM Stereo Radio Station

- ✓ Rock stable PLL synthesized
- ✓ Front panel digital control and display of all parameters!
- ✓ Professional metal case
- ✓ Super audio quality!
- ✓ 25mW and 1W models!



Our FM100B is the updated version of a truly professional frequency synthesized radio transmitter station in one durable, handsome cabinet. It is used all over the world by serious hobbyists as well as churches, drive-in theaters, and schools. No one else offers all of these features at this price! The included frequency display and audio level meters assist in easy operation. The "B" version now includes some additional functionality including a line level monitor output, improved stereo separation, spectral purity, audio clarity, and adjustable RF Output. An exclusive selectable microphone mixer and auto AGC circuit combines your local mic audio with your music input or mutes the music when mic audio is present. You don't even need an external mixer!

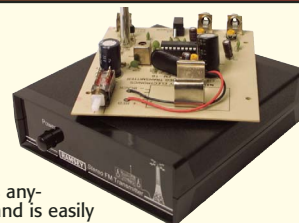
Sound quality is impressive; it rivals commercial stations. Low pass input filtering plus peak limiters put maximum "punch" in your audio, and prevent overmodulation distortion. No wonder everyone finds the FM100B to be the answer to their transmitting needs... you will too! The kit includes a sharp looking metal cabinet, whip antenna, and built-in 110/220 volt AC power supply. An external antenna connection allows hook-up to high performance antennas like our TM100 and FMA200. We also offer a high power export version of the FM100B that's fully assembled with one watt of RF power for miles of program coverage. Many islands and villages use it as their local radio station! The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported. (Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).

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FM100BEX	High Power Version, 5uW-1Watt Output	\$309.95	\$349.95
FM100BWT	High Power Version, 5uW-1Watt, Factory Assembled	\$389.95	\$429.95

### Professional Synthesized AM Radio Transmitter

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- ✓ Simple settings

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The transmitter accepts line level input from CD players, tape decks, etc. Includes matching case & knob set and AC power supply!

AM25	Professional Synthesized AM Radio Transmitter Kit	\$84.95	\$99.95
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### Tunable AM Radio Transmitter

- ✓ Tunes the entire 550-1600 KHz AM band
- ✓ 100 mW output, operates on 9-12 VDC
- ✓ Line level input with RCA connector



A great first kit, and a really neat AM transmitter! Tunable throughout the entire AM broadcast band. 100 mW output for great range! One of the most popular kits for schools and scouts! Includes matching case for a finished look! The AM1 has been the leading Scouting project for years and years. Try out your kit skills and at the same time...get on the air!

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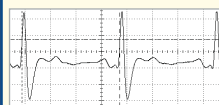
SMT and DDS technology is used throughout the SG560 for ultimate performance and reliability. If you're looking for a lab quality sig gen at a super hobbyist price, the brand new SG560 fits the bill...and a whole lot more!

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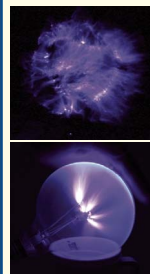


The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading every time! Multiple "beat" indicators include a bright front panel LED that flashes with each heart beat, an adjustable audio output to hear the beat, and of course, the monitor output to view on a scope, just like in the ER! Operates on a standard (and safe) 9VDC battery. Includes matching case for a great finished look. The ECG1 has become one of our most popular kits with hundreds and hundreds of customers wanting to get "Heart Smart"!

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Electronic Theories and Applications From A to Z

# Let's Get Technical

## Flash Conversion — Super Fast Analog-to-Digital Conversion

**A**nalog-to-digital (A/D) converters come in many shapes and sizes, but one major difference between one converter and another concerns the conversion time of the A/D converter. Is it fixed or variable? An application can get away with variable conversion time if it is not nec-

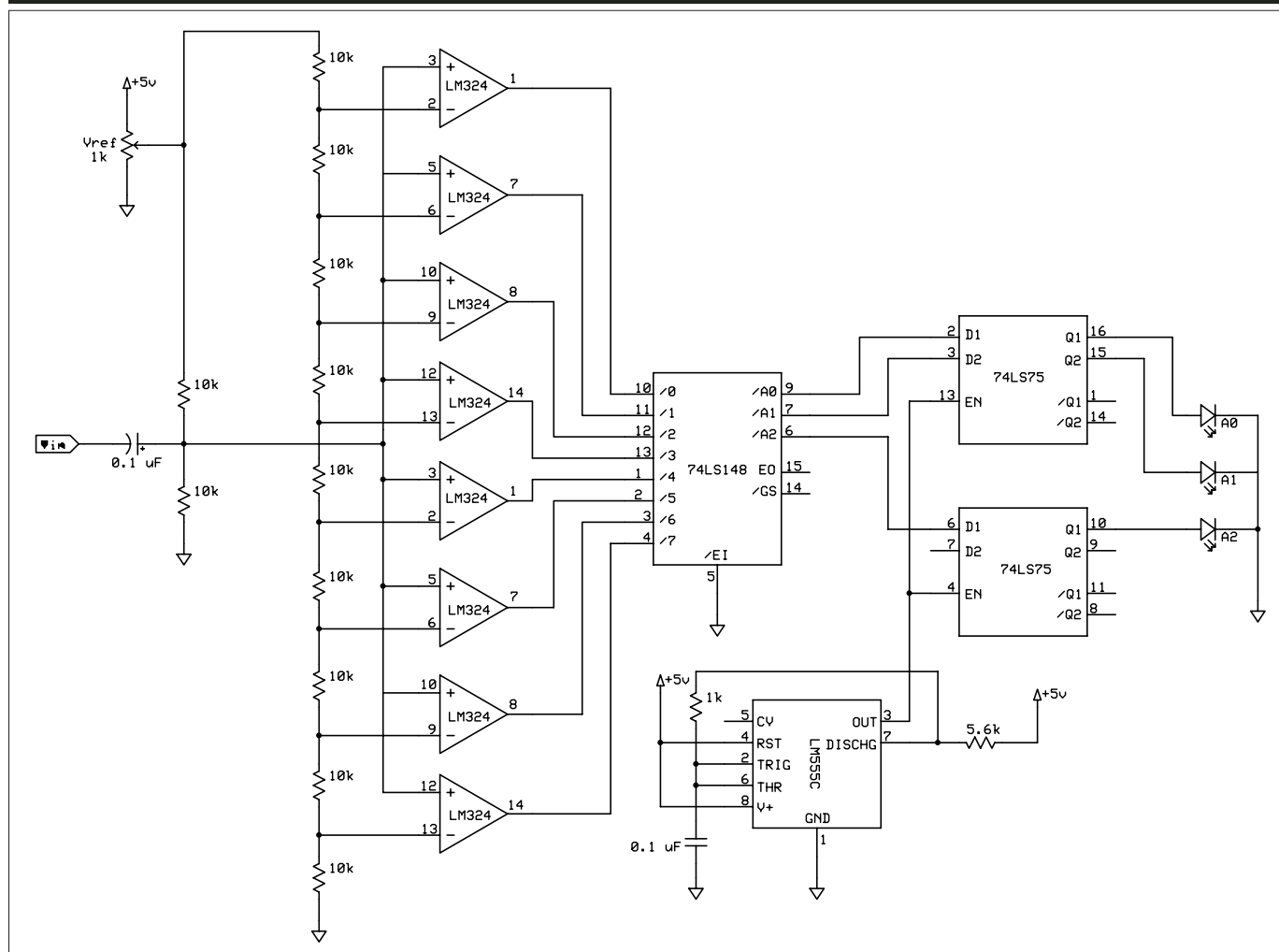
essary to sample the analog signal frequently.

A system that is monitoring temperature, for example, may use a thermistor to sense changes in temperature with the A/D converter sampling the thermistor voltage. Even if the system needs to sample the temperature 100 times each

second, that is still 10 milliseconds per conversion — plenty of time for a conversion. In this case, a dual-slope type of A/D converter will work fine.

Now, what about the technician who is designing a circuit to sample the analog output of a video camera? Each sample will represent one

**Figure 1.** Three-bit Flash analog-to-digital converter schematic.





pixel of image information. We want the pixels to look uniform, indicating that a fixed conversion time is needed. One scan line from the camera may need to be sampled hundreds or thousands of times, leading to required fixed conversion times in the nanosecond range. Here, we may choose to use a fixed time converter, such as a successive-approximation register, which typically requires one clock cycle per bit to perform a conversion (an eight-bit SAR would need eight clock cycles for each conversion).

We may also choose to use a Flash A/D converter, which has the benefit of a fixed conversion time in which all the bits of the output are determined at the same time (instead of one per clock cycle for the SAR). Figure 1 shows the schematic of a simple three-bit Flash A/D converter.

The key to the super fast conver-

sion time of the Flash converter is the combination of multiple comparators and a priority encoder. All of the comparators operate in parallel, each making its own comparison of the input voltage with a voltage level provided by a series resistor voltage divider. The individual comparator outputs go low or high according to their respective voltage comparison. The priority encoder then uses these comparison results to produce a three-bit output pattern that represents the input voltage.

Table 1 shows the input voltage range associated with each output pattern.

To find the voltage ranges, we begin by dividing the Vref voltage by nine (because there are nine resistors in the voltage divider). If Vref is set to five volts, this results in 0.56 volts across each resistor. Now, sup-

Input Voltage Range	Three-Bit Output Pattern
0.00 — 0.56	0 0 0
0.57 — 1.12	0 0 1
1.13 — 1.68	0 1 0
1.69 — 2.24	0 1 1
2.25 — 2.80	1 0 0
2.81 — 3.36	1 0 1
3.37 — 3.92	1 1 0
3.93 — 4.48	1 1 1

**Table 1.** Input voltage versus output pattern in the three-bit Flash converter.

pose the input voltage at Vin is (for an instant of time) equal to 2.5 volts.

Referring to Figure 1, the lower four comparators will have 2.5 volts present on their non-inverting (+) inputs and voltages less than 2.5 volts on their inverting (-) inputs. This will force the outputs of the

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INPUTS									OUTPUTS				
$\overline{EI}$	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$	$\overline{5}$	$\overline{6}$	$\overline{7}$	$\overline{A2}$	$\overline{A1}$	$\overline{A0}$	$\overline{GS}$	EO
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	L	H	H	H	H	H	H	L	L	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

**Table 2.** Truth table for the 74LS148 priority encoder. The highest numbered input that is low determines the output pattern.

lower four comparators high. The upper four comparators all have more voltage on their inverting inputs than on their non-inverting inputs, so their outputs go low. As a result, the /0 through /7 inputs of the priority encoder have the following values: L L L L H H H H. Take a look at Table 2, which shows the truth table for the priority encoder. The highest numbered input that is low is /3 (L L L L H H H H is the same as X X X L H H H H). With input /3 active, the output pattern

will be H L L (or 1 0 0). This is what Table 1 also predicts.

The 555 timer is used to control the 74LS75 latches that store a copy of the three-bit output pattern between samples. The 555 timer runs at a frequency of around 1,900 Hz. Sampling theory dictates that at least two samples are necessary each cycle to accurately sample a signal. This would limit the upper frequency at the Vin input to 950 Hz, and since this circuit was designed and built for demonstration purposes, this is acceptable. However, note that the conversion time of the Flash converter is a function of the gate delay of the comparators and the priority encoder, which puts the conversion time into the nanosecond range.

The input coupling capacitor prevents the converter from working with DC voltages, so a time-varying input signal must be used with this circuit. The coupling capacitor removes any DC offset present on the input signal, which prevents interfer-

ence with the biasing circuit used to center the input signal at a voltage equal to half of Vref.

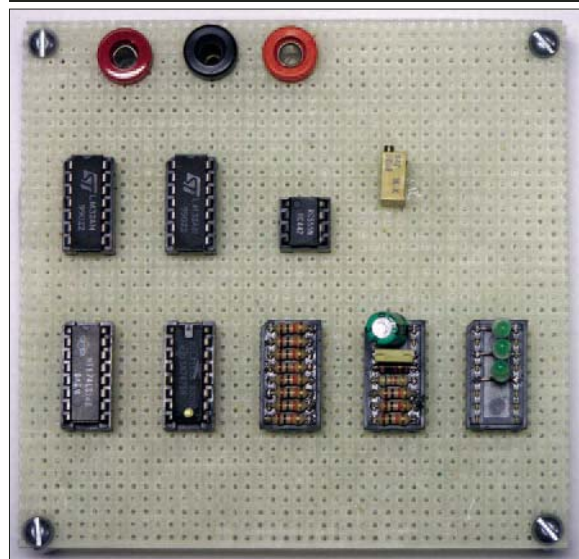
Figure 2 shows a breadboard of the three-bit Flash converter. The circuit was tested by applying a five-3volt, peak-to-peak sine wave with a frequency of a half cycle per second. This allowed the input voltage to change slowly, and we actually see the three output LEDs Flash accordingly.

As a little food for your brain, consider the following: If eight comparators are needed for a three-bit Flash A/D converter, how many are needed for a four-bit converter? What about an eight-bit converter? If you extend the hardware to additional bits, the number of comparators for an N-bit output will be  $2^N$ . So, a four-bit Flash converter will require 16 comparators, and the eight-bit Flash converter will require 256 comparators.

It is not very practical to make an eight-bit Flash converter in this way, but — with a little creativity — it is possible to make one using only 32 comparators.

First, use 16 comparators to determine the upper four bits of the eight-bit output. Then, use these four bits to create a voltage (with an internal D/A) that is subtracted from Vin to produce a difference voltage. This difference voltage is then converted using the second group of 16 comparators to determine the lower four bits of the output. Perhaps this process is accomplished in two clock cycles, which still gives us super fast conversion in a fixed time, but with a good deal of hardware savings. **NV**

**Figure 2.** The actual Flash converter circuit, wire-wrapped on a breadboard.



## About the Author

James Antonakos is a professor in the Departments of Electrical Engineering Technology and Computer Studies at Broome Community College and the author of numerous textbooks. You may reach him at [antonakos\\_j@sunybroome.edu](mailto:antonakos_j@sunybroome.edu) or visit [www.sunybroome.edu/~antonakos\\_j](http://www.sunybroome.edu/~antonakos_j)

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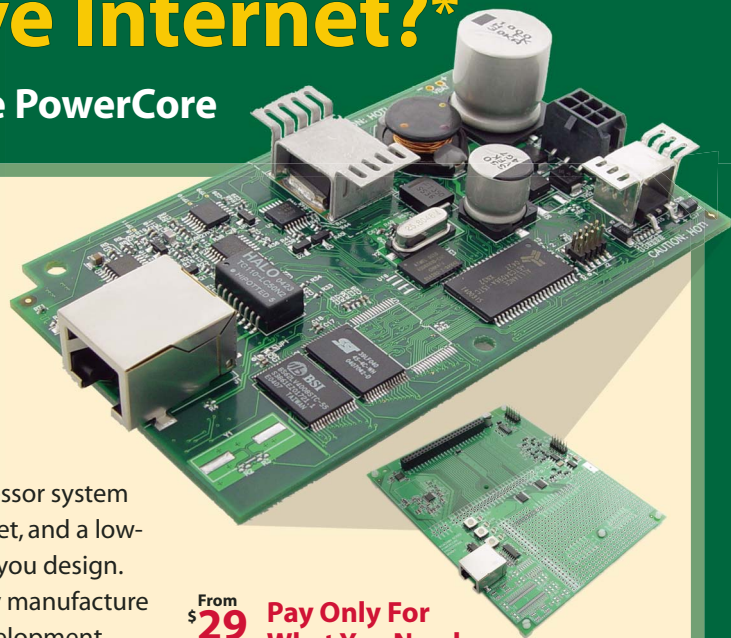
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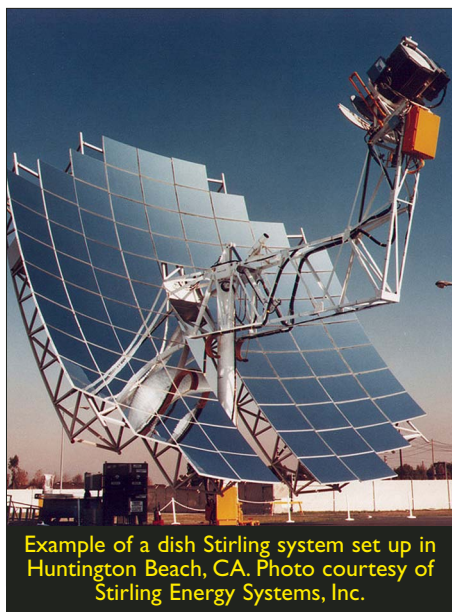
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— Jeff Eckert

## Advanced Technologies Solar Energy Plus a Stirling Engine



Example of a dish Stirling system set up in Huntington Beach, CA. Photo courtesy of Stirling Energy Systems, Inc.

**Y**ou are, no doubt, familiar with direct electrical generation using photovoltaic panels, but there is increasing interest in Concentrating Solar Power (CSP) technologies, which use reflective surfaces to concentrate the sun's energy and convert it to electricity via mechanical means. CSP tech-



Artist's rendering of a dish Stirling system power plant. Photo courtesy of Stirling Energy Systems, Inc.

niques are emerging as efficient and practical approaches for centralized power plants. One method uses a mirrored dish that continuously tracks the sun and focuses its rays onto a receiver, which absorbs the heat and transfers it to a Stirling engine. The engine then drives a generator.

The Stirling engine, by the way, was invented by Swedish minister Robert Stirling in 1816 and thus predates gasoline and diesel engines. It uses an external heat source and a cooler to raise and lower the temperature (and pressure) of an internal working gas, thus generating reciprocal motion between a hot and a cold piston. Stirlings are quiet, efficient (approximately 30 percent solar-to-electric conversion), and non-polluting.

Interestingly, if you turn a Stirling's flywheel, it works in reverse; i.e., it becomes a heat pump that can be used for refrigeration. (For a detailed explanation, see [www.sesusa.org/types.htm](http://www.sesusa.org/types.htm))

At present, Sandia National Laboratories ([www.sandia.gov](http://www.sandia.gov)) and Phoenix-based Stirling Energy

Systems, Inc. ([www.stirlingenergy.com](http://www.stirlingenergy.com)), are working with a six dish miniature power plant that is capable of producing 150 kW of electrical power during daylight hours. The ultimate goal is to build 20,000 systems that will provide substantial energy to southwest US utilities. The prototype cost about \$150,000.00, but that should drop to about \$50,000.00 in mass production, thus making it cost competitive with conventional fuel technologies. According to the researchers, a solar dish farm covering 11 square miles could produce as much electricity as Hoover Dam and a 100-by-100-mile installation could power the entire US.

## Smart Bombs for Tumors

**S**ometime in the future, cancer cells may be treated with tiny “smart bombs” that explode inside your body and deliver anti-cancer drugs with unprecedented accuracy. At least that's what Frank Caruso and his team at the University of Melbourne, Australia ([www.unimelb.edu.au](http://www.unimelb.edu.au)) have in mind. The process involves enclosing the drugs in polymer capsules sprinkled with gold nanoparticles that attach to tumor-seeking antibodies. You simply inject a load of the capsules into the blood stream, wait for them to migrate to the cancerous cells, and then explode them using a laser.

The capsules are created by adding a polymer material to a suspension of drug particles of about one  $\mu\text{m}$  width, forming multi-layered drug-laden spheres. Gold particles of about six nm diameter are added

and the capsules are then treated with a lipid outer layer and the antibodies. These entities can be exploded using a 100 mJ, 10 ns pulse from a near-infrared laser, which is relatively transparent to living tissue. In practice, the laser could be used externally to penetrate a few millimeters of tissue or be beamed to the interior via an endoscope.

The main snag at this point is that the process needs to be refined so that the capsules are much smaller — approximately 200 nm in diameter. Animal tests are said to be several years away.

## Computers and Networking Mozilla Problem Revealed

If you're using any version of the Mozilla browser earlier than 1.7.5, you may want to upgrade. It has been reported that the program contains a boundary error that causes it to mishandle "news://" addresses, resulting in crashes and the possibility that a hacker could use it to spread worms into your system.

Early Firefox and Thunderbird versions are plagued by some relatively minor problems related to how they store temporary files and downloads. The fix is easy: just log onto

[www.mozilla.org](http://www.mozilla.org) and download Firefox 1.0 and Thunderbird 1.0.

## First Holographic Drive Demonstrated

InPhase Technologies, a Bell Labs spin-off, has demonstrated a prototype of what is billed as the world's first holographic storage drive. The device forms the foundation for the company's Tapestry holographic drive family, with data capacities set to range from 200 GB to 1.6 TB on a single disk.

The mechanism records data on a patented two-chemistry photopolymer WORM material. The recording material is 1.5 mm thick and sandwiched between two 130 mm diameter transmissive plastic disk substrates. The device arranges more than one million bits of data into a single page, which is recorded with a single flash of a 407 nm laser beam. Multiple pages of data — referred to as a "book" — are recorded in one spot on the disk, providing approximately 12 MB of data in a single book location.

The prototype drive includes all drive subsystems, such as the auto load/unload mechanics, servo system, holographic read/write head, data channel, and electronics. At the

time of this writing, there was no information available as to when a commercial model will be available, as well as the anticipated price. For information, visit [www.inphase-tech.com](http://www.inphase-tech.com)

## Circuits and Devices Compact 35 W, Dual-Channel Amp Introduced



The APS-S50 supplies 35 watts into two channels or 50 watts into one. Photo courtesy of Flying Mole Corp.

Flying Mole (Electronics) Corporation (visit them at [www.flyingmoleelectronics.com](http://www.flyingmoleelectronics.com)) has added the model APS-S50 to its line of digital amplifier and power-supply combinations. While only about the

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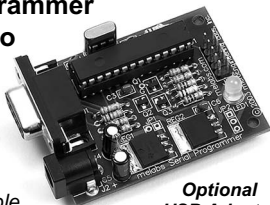
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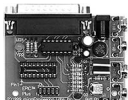
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size of a pack of cigarettes, it drives 35 watts into two channels or 50 watts into one channel. The APS-S50 incorporates Flying Mole's proprietary technology of docking each digital amplifier with the company's own low-noise power supply, which translates into its compact and lightweight qualities.

In addition, these amplifiers are said to be highly efficient, using 85 percent of electrical energy toward sound reproduction.

The compact size makes the APS-S50 suitable for compact digital sources — such as MP3s, CDs, or iPods — and the APS-S50 can drive speakers for equipment such as multi-zone distributed audio, game and karaoke machines, and other peripheral speaker systems.

By this spring, Flying Mole plans to incorporate this mini-amp into its Cascade series modular home theater amps with a multi-channel product that will be able to run 32 channels or more in three rack spaces. The amps are priced at about \$1.00 per watt and OEMs who are interested in the APS-S50

are encouraged to contact the company.

## DC Power Supply Provides Up to 1.2 kW



If you need a high-power, low-noise DC power supply and have \$1,725.00 to spend, you could consider B&K's model VSP4030. It offers as much as 1.2 kW in a 19 inch, rack-mounted chassis that measures just one U (1.75 inches) in height. The instrument — with an output of zero to 40 VDC and zero to 30 A — is designed for applications ranging from automatic test equipment and R&D labs to telecommunications. Up to nine units can be cas-

caded to produce more than 10 kW of DC power.

The VSP4030 is compatible with most computers via a standard RS-232 serial port and future models will provide communication via GPIB interface. Details are available at [www.bkprecision.com](http://www.bkprecision.com)

## Skiing Hazards Increase

If you are a skier, then you know that snowboarders are widely considered to be the punks of the slopes. If you drive a car, then you know that one of the most dangerous road hazards is a driver with a cell phone glued to his ear and his mind in outer space. What could be worse? How about a snowboarder with a cell phone built into his clothing?

Coming to a ski resort near you is a Bluetooth-enabled jacket designed by Motorola ([www.motorola.com](http://www.motorola.com)) in collusion with Burton Snowboards ([www.burton.com](http://www.burton.com)). It links a rider's cell phone and/or iPod to an embedded system that can be operated via a control module on the jacket sleeve. Stereo speakers are built into the hood of the jacket and a microphone is embedded in the upper section near the collar.

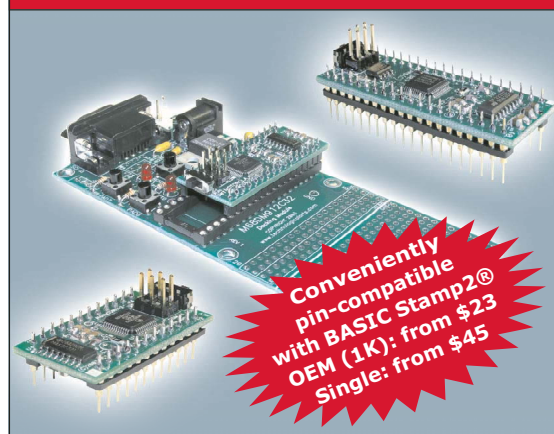
Various elements can be swapped between products, used as standalones, and then removed or reinserted. Also in the works is a helmet-beanie combination that keeps riders connected to their music and their phone. When the modules are removed from the helmet and beanie, they can double as a stereo headset.

For young, limber snowboarders and aging, gluttonous personal injury attorneys, it promises to be a lot of fun. Everyone else is advised to exercise caution.

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And while we're on the subject of cell phones, it has been noted

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that most of the 650 million units that will be sold this year will be thrown away within two years, placing various plastics, chemicals, and heavy metals in disposal sites. Part of the problem is the cheap plastic covers that many users buy to customize their phones' appearances. Riding to the rescue is Pvaxx Research & Development ([www.pvaxx.com](http://www.pvaxx.com)), which is about to introduce a phone cover made of a polyvinylalcohol polymer that biodegrades into something resembling soil after being discarded.

To make things even more interesting, each cover will contain a sunflower seed that can feed on the nitrates that are formed as the cover disintegrates.

Presumably, this will result in a plethora of sunflowers poking their heads up in landfills around the country. Motorola is a participant in this concept as well, and, in fact, requested that Pvaxx develop the product.

Rumors that a special Oregon version of the cover will contain a different kind of seed remain unsubstantiated.

## Industry and the Profession

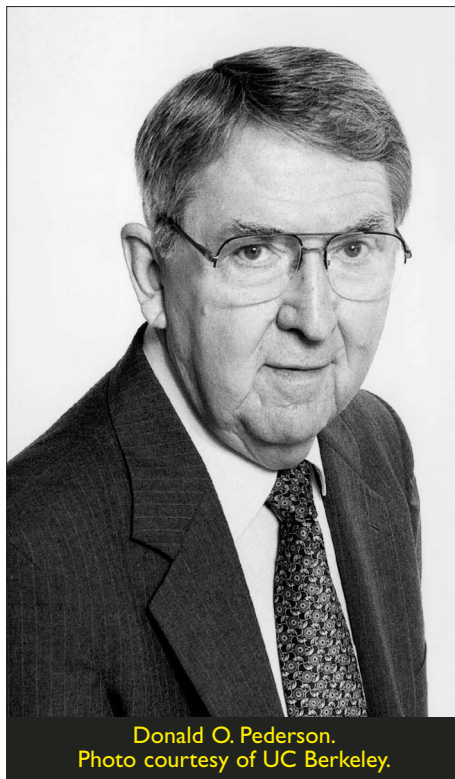
### IBM PC Details Announced

As previously and widely reported, IBM has agreed to sell its PC operations to the Beijing-based Levono Group for \$1.25 billion, moving it out of the business for the first time since 1981. A recent IBM filing with the Securities and Exchange Commission shed new light on the reasons behind the move.

Apparently, the division has lost nearly \$1 billion since January 2001, including \$139 million in the first half of 2004, \$258 million in 2003, \$171 million in 2002, and \$397 million in 2001.

## RIP, Donald O. Pederson

Donald O. Pederson — one of the inventors of the Spice language



Donald O. Pederson.  
Photo courtesy of UC Berkeley.

and a University of California Professor Emeritus — died on December 25th at the age of 79 from complications of Parkinson's disease. Pederson is credited as one of the inventors of the Simulation Program with Integrated Circuit Emphasis language, the first design language for simulating circuit behavior and the first open source language.

Pederson gained many honors during his illustrious career. He was elected as a member of the National Academy of Sciences in 1982 and the National Academy of Engineering in 1974.

Other honors and awards included a Guggenheim Fellowship in 1968, an American Association for the Advancement of Science Fellowship in 1988, the Berkeley Citation in 1991, the Phil Kaufman Award from the EDA Consortium in 1995, and the Institute of Electrical and Electronics Engineers' Medal of Honor Award in 1998. Pederson also received an honorary doctorate from Katholieke Universiteit Leuven in Belgium. **NV**

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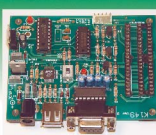
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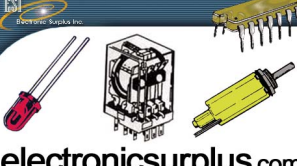


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## Customer Comment of the month:

"Thanks for your outstanding care and follow up! We changed our installation manual and now everything is ok."  
(Giovanni)

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# Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at:  
**TJBYERS@aol.com**

## What's Up:

A couple of cell phone solutions — and stories.

Need help designing dipole antennas? Find it here. An AC line monitor, low-battery disconnect, and a wideband RF sniffer. Finally, a cool, free software website.

## AC Line Monitor

**Q.** My local power distributor tends to exceed the 126-volt limit set forth by the utility commission. I would like an alarm circuit that would activate a Sonalert at precisely 126.0 VAC and above. I have tried simple op-amp circuits, but they drift about 0.5 volts due to room temperature variations.

**Thomas  
via Internet**

**A.** The drift is caused by a combination of components — not the op-amp alone. This includes the reference voltage, divider resistors, and op-amp-input-offset-temperature coefficient. Where to start is with a precision voltage reference, like the REF03. It has a temperature coefficient of 20 ppm (parts per million) per degrees Celsius with a guaranteed reference voltage of 2.5 volts, plus or minus 0.015 volts.

This is input to an LM339 comparator (Figure 1), which has a 1.0 nA input-offset current that is magnitudes better than a garden variety op-amp, like the LM324. The final ele-

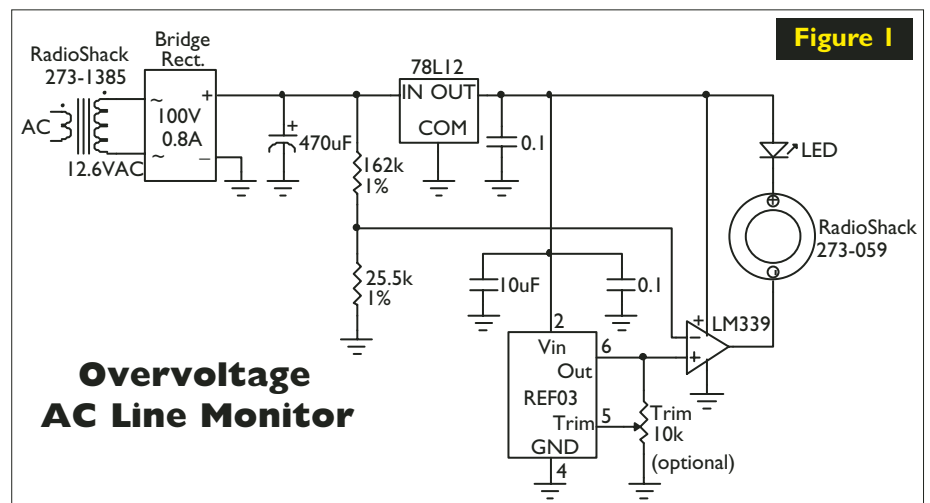
ment is the resistance divider that senses the AC input voltage. Again, this is a source of temperature drift. Thin-film, one-percent resistors are the most stable — especially the SMD (Surface Mount Device) type.

When the voltage from the resistance divider exceeds 2.5 volts, the comparator output goes low and sounds the alarm. The values of the resistors are selected so the alarm sounds when the voltage exceeds 126.0 volts. For better accuracy, use the optional Trim control to set the exact trip point (it isn't necessary for most applications).

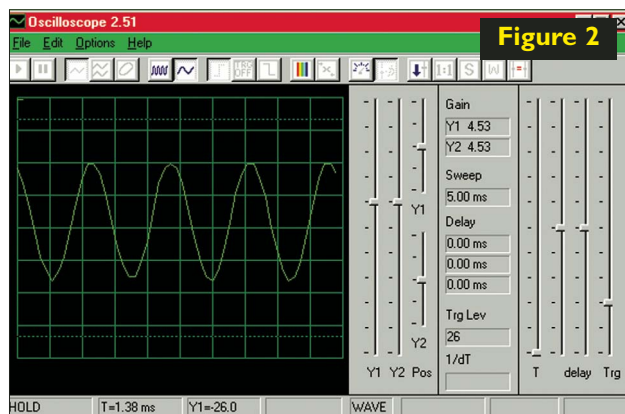
What about hysteresis, you ask? I'm counting on the 470  $\mu$ F filter cap — with a response time of about 0.5 seconds — to keep the detector from chattering.

## A Heart Rate Monitor Monitor

**Q.** In the November 2004 issue, I saw an ad for a heart rate monitor (Ramsey Electronics, page 21). However, this monitor only outputs an analog signal. Can you suggest a circuit with simple software that will







**Figure 2**

allow me to input the signal to my computer and read/store the results?

**John Shavers  
via Internet**

**A.** According to Ramsey, you can display the heartbeat on an oscilloscope — which you can easily install on your PC using software. There are several packages to choose from and most of them are free.

My favorite is Winscope. This dual-trace oscilloscope is made by converting the audio signals of the left and right inputs of the sound card into digital numbers using the

card's onboard ADC. When connected to Ramsey's Electrocardiogram Heart Monitor, it has the look and feel of being in the ER.

## The Audio Route

**Q.** I am in need of a circuit that I can build for an audio

switching control center. I have two tape-to-tape decks, one CD recorder/playback deck, one reel-to-reel deck, and one turntable ... at present. I would like to be able to switch among them in both directions in any combination of playing or recording.

Currently, I feed my audio into a power amplifier, but it doesn't have enough inputs/outputs to accommodate all the decks and switching arrangements. I need at least eight inputs/outputs in all to handle additional audio equipment slated for this audio control center. Any information that would help me accomplish my goals would be appreciated.

**Tony A.  
Wappingers Falls, NY**

**A.** What you need is a crosspoint switcher, which can be either mechanical or electronic. Since you want the connection to be bi-directional, your best bet is SPST toggle switches. They are cheap, easily wired, and have virtually no contact resistance. Best of all, there is no distinction between in or out.

A schematic for a four-by-four crosspoint switching matrix is shown in Figure 3. Why just four choices when you want eight? Because of space on this page, and an eight-

by-eight drawing would be just too big. The circuit is easily expanded in either direction by row or column by adding additional switches, which means matrices of eight-by-four or four-by-six are well within the realm of this design.

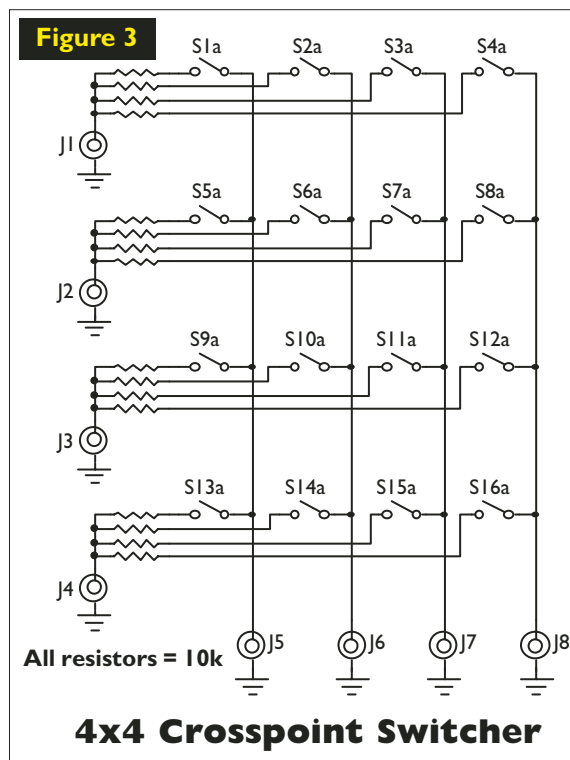
The 10K resistors are used to minimize crosstalk between the channels and are not an option. If you find crosstalk to still be a problem, the solution is to increase the size of the resistors (with added signal loss) or replace them with buffered op-amps (unity-gain voltage followers). A buffer amp will, of course, prevent bi-direction signal flow.

You may notice that the switches are labeled S1a, S2a, etc., and they all have an "a" designation. That's because you can add a second matrix to the first by changing the SPST switch to DPST (S1b, S2b, etc.) and replacing the 10K resistor with an LED-1K combination that would light when that switch is closed. When the LED is placed near the switch itself, it makes for an impressive looking control board. Black lines representing the signal paths would be a finishing touch.

## Boosting Cell Phone Signal Strength

**Q.** We live outside the high desert town of Victorville, CA, and are forced to use a cell phone (no land line). We can barely receive a signal in the house and, outside, the signal is marginal. My wife talks at length to her daughter ... standing outside.

Raising the phone in the air increases signal strength significantly. Our house is stucco with chicken wire underlay, which is essentially an RF cage. I am thinking of trying to increase the signal strength in the house by placing a resonant antenna above the roof line with a matched coax feed line. Its lower end would be terminated in the house with a small, possibly tuned, (850 MHz) wire loop.



**4x4 Crosspoint Switcher**

To use the phone, you would slip its stubby antenna into the loop. (Maybe a 300-ohm line and a vertical folded dipole would be best.) Could this work? Can you refine this idea or do you know of a better solution to this problem?

**Walt Brackmann**  
via Internet

**A.** Yes, this is one answer. Figure 4 shows the dimensions of a folded dipole antenna design for 850 MHz. I'd mount the antenna elements on a square of Plexiglas for rigidity and put it on a mast (broomstick?) mounted on the roof. Hang the antenna loop inside the house in a convenient location and bring your cell phone antenna close to it when talking. I wouldn't put the phone antenna inside the loop — it may detune it. Now, I can't promise this will solve all your cell phone problems — or any of them, for that matter — but it's worth a try and doesn't cost an arm and leg to test your theory.

Let me say once and for all to those readers who have the same dilemma — and who clutter my email box with the same question — that there is no sure cure. The frequencies at which cell phones operate are essentially line-of-sight communications. That is, if there's a hill or building between your cell phone and the tower, the signal will be at least attenuated if not blocked. The ultimate solution is to put a cell tower on every street corner (don't laugh — it's coming) or go to satellite. Until then, you can always star gaze while you're talking on the roof.

## Rectenna Relief

**Q.** I am searching for a simple circuit that could pick up my ship's radar signals — about 10 GHz. My idea is to assemble a PIN or Schottky diode into a metal can, a microwave amplifier, and a buzzer (or s-meter). Assembling this stuff confuses me.

**Patrick Montaron**  
Tahiti/French Polynesia

**A.** If you want to do it fast, use a radar detector like those sold for detection of police radar guns. Cobra sells them for as low as \$37.00. You asked for a simple circuit that you can build yourself, though; this is why I'm here.

I think a dipole rectenna is your answer. A rectenna is an antenna that rectifies the 10 GHz signal and turns it into DC voltage. Using the formula  $L=468/f$  (where  $f$  is in MHz), the length of the dipole elements equals about a half inch. At these dimensions, the rectenna can be built on a printed circuit board using the copper tracks for the dipole elements — as shown in Figure 5.

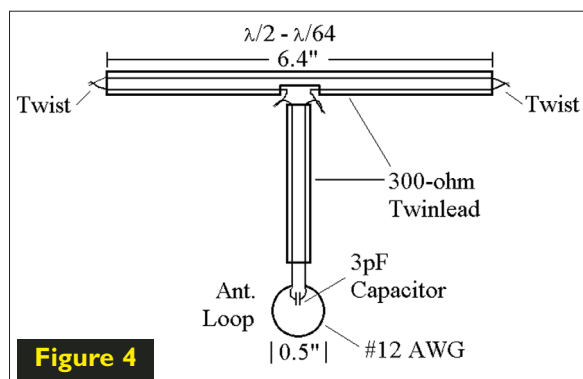
The Schottky diode is a surface-mount device that solders to the copper strips. A voltage is developed across the diode when it receives a 10 GHz signal — and lights the LED. The LED doesn't have to be mounted on the PC board. You can run wires from the rectenna to an LED, optoisolator, buzzer, or voltmeter.

## RF Detector With Digital Output

**Q.** Would you know where I could find or make a simple (cheap) RF detector? What I need is a digital signal line to go active high each time I key my two-meter radio (144 MHz). I would like the detector to be sensitive enough to not need a long antenna. I would also like to do the same for the 70 cm band (440 MHz).

**Phil Blake**  
via Internet

**A.** The following circuit is a long-time staple of the ARRL community (Figure 6). I simply replaced the buzzer with a 5.1 volt zener diode to generate your digital output pulse (I left the LED). This RF sniffer will respond to frequencies between 500 kHz and 500 MHz with, of course,



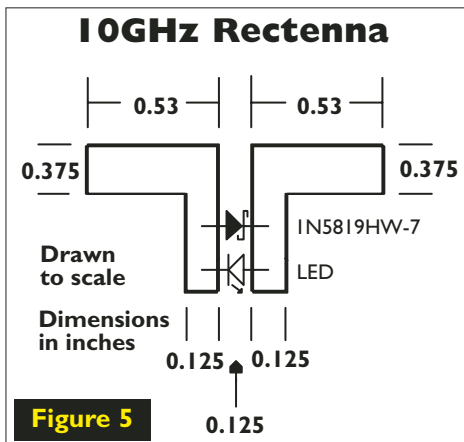
**Figure 4**

varying sensitivity. I suggest using a telescoping antenna so that you can "tune" the detector by antenna length (kind of). It's been said that this detector isn't all that sensitive, but I see no problem, unless you are a QRP person.

## Phantom Cell Phone Ringer

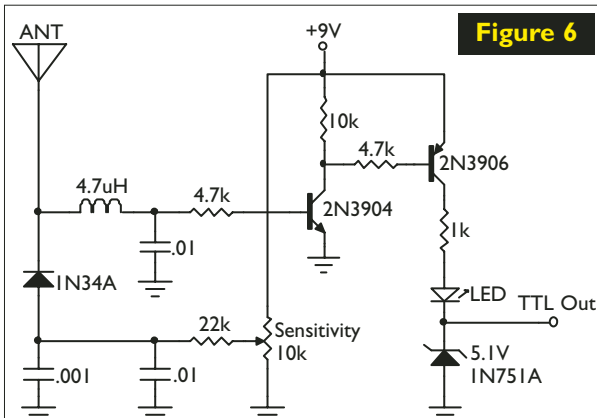
**Q.** My wife has severe high frequency hearing loss and cannot hear the ring tones (tunes) when a call is received on her cell phone. The phone manufacturer (Nokia) says the ringer will not reproduce low frequency sounds. Simply making the current tones louder will not help and using vibration for sensing is impractical. I need an add-on to detect the present ring and sound an alarm. It needs to be self-contained without modification to the cell phone. Any help will be appreciated, as this is badly needed.

**Wade Bovender**  
Greensboro, NC



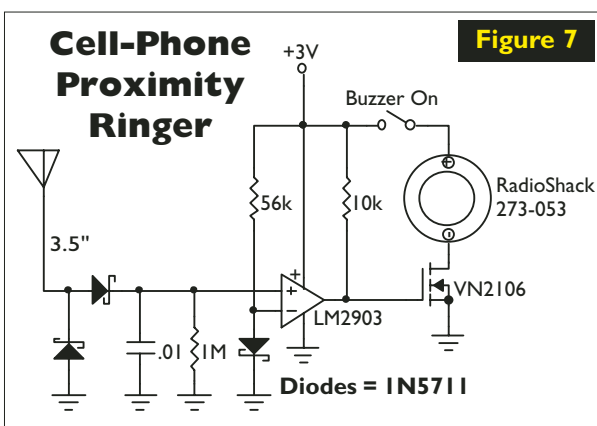
**Figure 5**





**Figure 6**

## RF Sniffer 0.5 - 500 MHz



**Figure 7**

## Cell-Phone Proximity Ringer

Diodes = 1N5711

**A.** Here's a little known fact: Before your cell phone rings, it comes to life and begins transmitting. When the cell tower receives a request from a caller to ring your phone, the tower first has to find you. It does this by sending out a "Where are you?" request. When your cell phone hears this, it responds by saying, "Here I am, alive and well." The two then shake hands to establish a link and set the billing machine in motion. After that, your phone rings.

We can use this sequence to create an external ringer by sensing the transmission with a simple receiver (see Figure 7). A Schottky diode rectifies the RF from the antenna and inputs it into the input of the comparator. A third Schottky diode is connected to the reference input. When the RF signal exceeds the voltage of the reference input, the VN2106 MOSFET turns on and sounds the 300-

**Q.** I'm trying to figure out how those call-activated cell phone stickers work. I've also seen the ones that attach to the antenna and perform an LED chase pattern when the user is talking on the phone.

**James Tu**  
via Internet

**A.** Both the patch and antenna clip receive their power from the RF generated by the cell phone. Unlike the proximity ringer above ("Phantom Cell Phone Ringer"), the LED flasher has to be in intimate contact with the antenna in order to receive enough power for the LEDs. The patches are designed for use with GSM cell phones with an internal antenna and glue to the body of the phone. The clips are designed for use with GSM cell phones with an external antenna. Carriers that use the GSM system include AT&T,

500 Hz buzzer. The buzzer will continue to sound the entire time the phone is in use. This is quite annoying, hence the reason for the Buzzer On switch, which turns the buzzer off during the conversation. Just don't forget to turn it back on after hanging up.

The receiver has a range of three to six inches, depending on the make and model of the cell phone. This means you can slip it into a pocket close to the cell phone without having to resort to duct tape to attach the ringer to the phone itself.

Don't feel like building the circuit? Check out the next question, "Cell Phone Charms."

## Cell Phone Charms

Cingular, and T-Mobile. These displays won't work with Verizon or Sprint cell phones.

## MAILBAG

Dear TJ,

Well, I finally got my dip meter (January 2005) working and calibrated. My meter can now measure frequencies up to 108 MHz. Thanks for the help! One more question: When building a dip meter, what kind of project box do I need — plastic or metal?

**James Ko**  
via Internet

*I'd use a plastic case for this project. — TJ*

Dear TJ,

In the November 2004 discussion on thermocouple junctions, you stated that the voltage is, "Generated across the length of the wire." I think that it might be more accurate to state that each junction — hot and cold — acts as a battery (electron diffusion causes these potentials) and that the two batteries are in series with reverse polarities. I hope this helps clarify a phenomenon that often causes confusion.

**Tony du Bourg**  
via Internet

## Cool Websites!

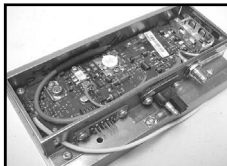
The **Moon Calendar** shows the phases of the **Moon** for each day of a selected month. You can set the calendar to any date from 3999 BC to 3999 AD.  
<http://users.ameritech.net/paulcarlisle/MoonCalendar.html>

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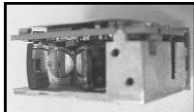


## CCFL Florescent Light Inverter



New power inverter drives 2 lamps up to 5W each! Simple to use, 12 VDC in, connect florescent lamps to output. Module generates correct starting and operating voltage, lamp current and is even dimmable!  
0128520R .....\$9.95

## Laser Scanner Bar Code Module



Wow! What a cool item! Brand new laser scanner module (size 1x1x1.5") includes red laser, beam splitting mirror, opamps, photo sensor, transistors, processor, ICs, etc. From handheld laser barcode reader. We sold out of the last style we had! No specs, but buyers figured out the hook up for the last group, we'll post on the web any new info on this one, should be easy, has just 12 pins on the connector. Styles may vary.  
0131346R .....\$14.95

## Piezoelectric Alarm



WOW, is this thing LOUD! Runs on 2 12 VDC and draws mere milliamps, 103db output! Rotating bezel allow easy volume control too! 1.25" dia and 1.5" long. Google for specs: Bell Audiolarm XC V09 212 S  
0132165R .....\$4.95

## Watch Camera Button Battery

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## LED BLOWOUT !!!



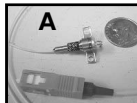
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0130955R Box o leds Green 2,000pcs \$19.95

## Windsor's Blue LED Special



Holy Smokes! Can you believe the price on this BLUE LEDs? First quality from our factory buyout. Big and bright! These normally sell for \$1.50 each and that's in big quantities! We're crazy to sell 'em so cheap!!  
0131297R 50pcs \$19.95  
0131297 500pcs \$99.95

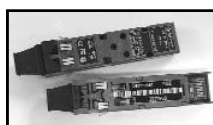
## Laser Fiber Optic Transmitter



Brand new HP Agilent model LST2829 Laser transmitter module. Capable of 622 MB/s data rates, 1 mW output power, 1300 nm wavelength, includes on chip power monitor diode. These are high end quality lasers and not often found on the surplus market! Two style available, A: 32" long thin pigtail fiber and B: 16" long encased fiber. Each has the same electrical specs. Price: \$9.95 each  
Item A: 0128526R Item B: 0128536R

## Laser Fiber Optic Transceiver

New, by Infineon. Has laser transmitter and receiver in one package! 1.25 Gb/s data rate up to 700 M on low cost multi mode fiber! Super small size, complete specs on the web. Make your own fiber optic link!  
0125461R (Set of two) .....\$19.95



## Tiny Beeper Speaker

Star PMX 04B beeper speaker as used in cell phones and pagers. Only 1/2" dia, easily drive from micro or single transistor driver circuit included!  
0133088R Group of 5 pcs .....\$2.00



## C size Nicad Battery



This is the real deal, a true 2 A Hr Nicad, Button top works in any device too! Brand new by Sanyo.  
0130380R .....\$2.00



## Nicad Battery Stick

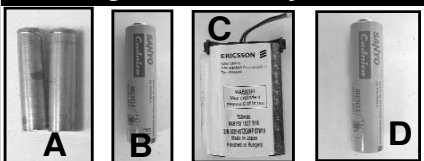
New 4.8 V 500 mAh Nicad battery. 0133511R.....\$4.00

## Ion Generator



Its super easy to build your own Ion Breeze air purifier! New module, 120 VAC in, 7.5KV out! Surplus from air cleaner maker who sold them for \$200!  
0128873R .....\$7.95

## Rechargeable Battery Blowout!



Popular Nicad batteries, 1.25V All brand new. A, B, D are NiCad, C is NiMH. A has no sleeve.  
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B: AAA 250 mah 0133089R 5 for \$3.00  
C: 3.6 Volts 750mah 0125348R 2 for \$3.00  
D: AA 700mah 0132163R 5 for \$3.00

## Nicad Battery Pack

Brand new high power density rechargeable battery pack. 6 volts, 650 mAh. Space saving rectangular shape approx 2x1x0.75" with 6" wire leads.  
0132161R .....\$4.95

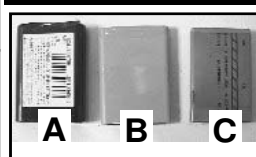


Nice, new 5 AA cell nicad pack. 6 Volt 700mah with 6" wire leads. Great for projects or cordless phone replacements.  
0125345R.....\$2.50

Big box of 50 brand new AA button top NiCads. Fit anywhere an AA battery does. 1.25V 800mah. Best price in the USA!  
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## Lithium Ion Rechargeables !!



Rechargeable Lithium batteries pack the highest density of power for size and weight! Ideal rectangular size is easy to fit in your project. All 3.6 Volt and approx rated Amp Hour capacity.  
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B: .8Ah 1.95x1.34x.25" 0125349R.....\$1.25  
C: .8Ah 1.95x1.24x.23" 0125350R.....\$1.25

## Truck Stereo



New in dash cassette stereo AM/FM radio, LCD display, drives 4 speakers (80 watts!) Even has Weather band! Quality

fully enclosed case, easy hookup, great for in wall home installations! Runs on 12 VDC.  
0128872R.....\$29.95

## Handy Tool Set

Well made quality 3 piece plier set. Includes deluxe padded zipper case. Pliers are big 8" in size, you get: needlenose, diagonal and lineman style with handy crimper and stripper dies on each tool! Get a few for the car, gifts and toolbox, they are that nice!

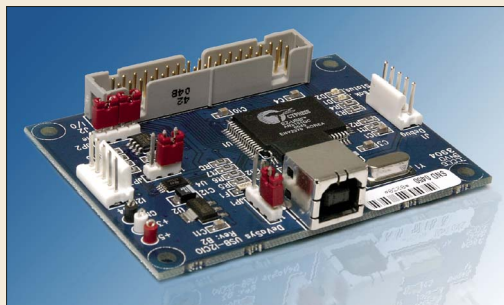


0128871R .....\$12.95

**www.shopatwindsor.com**



## USB-I<sup>2</sup>C/IO — INSTANT SOLUTION FOR I<sup>2</sup>C CONTROL FROM PCS



**S**aelig Co., now has the USB-I<sup>2</sup>C/IO interface board available. It provides a simple “drop-in” 12 Mbps USB interface to a host PC for quickly connecting external hardware. USB-I<sup>2</sup>C/IO provides 20 bits of user-configurable digital I/O, a 90-Kbps I<sup>2</sup>C interface, and an eight-bit wide data bus for fast FIFO transfers.

USB-I<sup>2</sup>C/IO is a small (3.0 x 2.25 inches) board useful for a wide range of applications, such as: USB interfacing to 90-kHz I<sup>2</sup>C components, USB to 20 x I/O connections like LEDs or switches, I<sup>2</sup>C test fixture interfacing, data acquisition, etc. A handy USB status LED lights on enumeration and blinks to indicate USB traffic. (It turns off when traffic is suspended.)

The full-speed USB interface provides your application hardware with a “Hot Plug and Play,” 12 Mbps, industry standard connection to a PC host, using Cypress’ AN2131QC USB microcontroller. A power configuration jumper allows USB-I<sup>2</sup>C/IO to be powered by USB or by external circuitry. The included device driver, DLL, and example application software make it easier to access your application hardware from a PC.

The software provides support for connecting multiple boards. This makes the USB-I<sup>2</sup>C/IO a great solution when multiple equipment instances are required (test fixtures, production equipment, instruments, etc.). Each board can be uniquely identified by the application software via a serial number.

The board can be configured to download its firmware upon connection to the PC or to boot from the I<sup>2</sup>C bus. An onboard I<sup>2</sup>C EEPROM is included on the board, providing 16 KB of storage for code or data.

For more information, contact:

### SAELIG CO.

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Pittsford, NY 14534

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Fax: **585-385-1768**

Email: **info@saelig.com**

Web: **www.saelig.com**

Circle #51 on the Reader Service Card.

## CIRCUIT CREATOR STANDARD ELECTRONIC CAD SOFTWARE

**A**dvanced Microcomputer Systems, Inc., has announced the availability and shipping of Circuit Creator Standard™ Electronic CAD software for hobbyists and small companies. It also includes schematic capture and PCB layout editors. The software comes with a 400-page instructional book, *Electronic CAD Made Easy Using Circuit Creator*.

This fourth-generation software includes printed circuit board layout editor, along with schematic design and capture software with built-in symbol editor. The product is available from stock directly from AMS, at a suggested retail price of \$195.00.

The Circuit Creator system includes the best selling Logic Creator™ schematic design and capture software. This software provides facilities for full hierarchical schematic creation and editing, while providing online, on-demand context-sensitive help.

Users can design up to “E” size schematics in a single file, with additional sheets linked using hierarchical designs. The most important module of Circuit Creator is Board Creator™ printed circuit board design software. Board Creator can interactively and automatically check for errors, and design rules while editing. It allows interactive component placement, support for blind and buried vias, as well as automatic footprint mirroring for surface mount device support.

According to Terry Harte, AMS Chief Engineer, “Logic Creator provides a full design rule and error checking environment. It helps engineers design out errors, thus providing an essential tool for Quality-By-Design. You can go directly from schematic design to error-free PCB artwork or easily import an existing design into Circuit Creator.”

The software includes important features that are available only in high-end products:

- A user-expandable symbol library of over 25,000 components that allows user-defined symbols to be added easily.
- Object-oriented parts and symbols with DeMorgan equivalents, rotation, and mirroring of parts from a single definition.
- Symbols are vector-based, allowing more flexibility. Automatic rerouting of connections of moved symbols makes schematic routing very easy.
- True Bezier curves instead of curved lines make Logic Creator very flexible to use. Line widths and colors may be assigned to specific schematic elements for improved

clarity and understanding.

Circuit Creator Pro™ software includes additional features: copper pouring, support for 32-inch by 32-inch large board size, and up to 256 multi-layer board designs. The Board Creator has a built-in one-click Gerber and Laser Photoplot output feature. The software supports RS274D and RS274X Gerber file formats. It also allows the user to view photoplot files.

For more information, contact:

## ADVANCED MICROCOMPUTER SYSTEMS, INC.

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Web: [www.advancedmsinc.com](http://www.advancedmsinc.com)

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## PIC PROGRAMMING MADE EASY

**R**4 Systems is now an authorized reseller of the PICBASIC Proton Development Suite. The Development Suite represents a quantum leap forward in the development of Crownhill's PICBASIC product. This Development Suite incorporates a brand new IDE (Integrated Development Environment) and a Virtual Simulation Environment Creator that has been described as "the very best of breed" solution for working with the Microchip Technology PICmicro® microcontrollers.

The Suite is suitable for all levels of users, from outright beginners to seasoned professionals writing commercial applications. The IDE/Compiler will allow you to develop your code in a state-of-the-art development environment, compile your program code, and view the resulting assembly language commented with your own program code. The output of the compiler is 100 percent Microchip MPASM-compatible and the resulting Hex file, COD, ERR, and LST files can be used with Microchip-compatible programming tools.

Included with the Development Suite is a fully working, highly acclaimed Proteus Virtual Simulation Environment. The Proteus Simulator provides near real-time simulation of your code on Virtual Proton Development Boards. Proteus Virtual System Modeling (VSM) combines mixed mode SPICE circuit simulation, animated components, and microprocessor models to



facilitate co-simulation of complete microcontroller-based designs. On top of all this is step-by-step code execution for source level debugging. Now, it is possible to develop and test designs before a physical prototype is constructed.

The Proton IDE is a professional and powerful visual IDE, which has been designed specifically for the Proton Plus compiler. Proton IDE accelerates product development in a comfortable user environment without compromising performance, flexibility, or control. The compiler has enhanced support for I<sup>2</sup>C, SPI, Dallas one-wire bus, RS232, X10, compact Flash cards, alphanumeric and graphic LCDs, and USB interface.

The Proton Development Suite is available at the introductory price of \$255.00.

For more information contact:

## R4 SYSTEMS, INC.

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Newmarket, ON L3Y 8Y8

Canada

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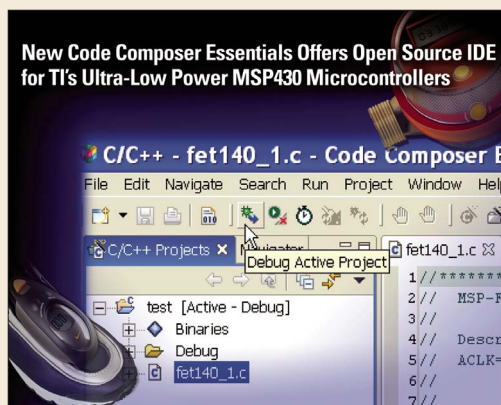
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## OPEN SOURCE IDE FOR TI'S ULTRA-LOW POWER MSP430 MICROCONTROLLERS



**D**eveloping its first open source integrated development environment (IDE), Texas Instruments, Inc., announced the availability of Code Composer Essentials (CCEssentials) IDE for the MSP430 family of ultra-low power microcontrollers (MCUs). Based on the Eclipse open source platform, CCEssentials allows designers and third parties to easily integrate updates and plug-ins to pro-

vide a highly customized and flexible IDE. The CCEssentials IDE was designed specifically to offer users an intuitive interface combined with the industry's highest C code density for reducing time to market at a lower total system cost. For more information on CCEssentials IDE, see [www.ti.com/cc essentials](http://www.ti.com/cc essentials)

### First IDE developed specifically for MSP430 Microcontrollers

"The popularity of the MSP430 made it important for us to offer a robust IDE with the highest code density directly from TI," said Mark Buccini, Advanced Embedded Controllers marketing director. "Developers can now leverage the benefits of open source tools with the added advantage of MSP430-specific optimization to make development extremely efficient and intuitive enough for users to get started in less than 30 minutes."

Based on the experience from developing award winning, highly integrated IDEs like Code Composer Studio (CCStudio), the CCEssentials IDE features an intuitive interface, one-click debug option, and TI compiler and code generation technology that allows users to start programming almost immediately.

### Eclipse Open Source Enables Interoperability for Flexibility and Innovation

The CCEssentials IDE is based on the Eclipse open source development platform, which offers developers the freedom of choice in tool integration, software modeling, and testing in a multi-language platform and vendor environment. Eclipse provides customizable tools and a plug-in based framework for designers and third parties that simplifies the creation and integration of software tools from various sources to reduce development time and money.

The Eclipse platform enables a high level of interoperability allowing designers the option of using a different host OS, debugger, or compiler based on their preference. The large community of developers allows users to access continual upgrades and extensions, and modify tools to suit individual needs through bug fix contributions and complementary product integrations like source code editors and unified modeling language (UML) design tools.

It also provides ready access to significant developers' resources on the web, in published books, in newsgroups, and on developers' network mailing lists. By collaborating and exploiting core integration technology, tool producers can leverage platform reuse and concentrate on core competencies to create new development technology.

For more information, contact:

**TEXAS INSTRUMENTS, INC.**

Web: [www.eclipse.org](http://www.eclipse.org)

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## Digital Nuts & Volts is Coming Soon TO A COMPUTER NEAR YOU!



If you answered "yes" to any of the questions above, you may be interested in a new feature *Nuts & Volts Magazine* will soon offer. In addition to your regularly printed issue, you will also be able to receive the magazine on a disc — completely searchable, printable, and easy to store. Starting with 2005, it is possible to get a whole year's worth of issues on one collection of discs.

To express interest in this optional service, email us at [CD@nutsvolts.com](mailto:CD@nutsvolts.com)

## SPYFINDER DETECTS AND LOCATES HIDDEN CAMERAS

**T**he SpyFinder hidden camera detector/locator from M. J. Electronics is a reliable and easy-to-use technology that makes securing your private actions possible. Its function is based on the principle of optical augmentation. This technical jargon refers to the phenomenon where light reflected from a focused optical system — such as a video camera — is reflected along the same path as the incident light. This means that if a hidden camera is illuminated and viewed with the SpyFinder technology, then a strong reflection from the target camera will reveal its position to the user. The SpyFinder exploits this phenomenon by using a ring of ultra-bright LEDs arranged around a viewing port. When a user scans a room looking through the viewing port, a hidden camera appearing in the field of view will brightly reflect the light from the LEDs.

### Operation

While the equivalent of rocket scientists thought up the SpyFinder technology, operating it is not rocket science. Simply look through the viewing port and depress the button to activate the LEDs. Slowly scan areas where hidden cameras are suspected to be and look for bright reflected spots. Remember, most hidden video cameras use pinhole camera lenses, so the spot you are looking for could be small.

If you see a suspected camera, move your vantage point slightly. If the location of the reflection moves as you move, then this is not a camera. If the location of the reflection does not move, then it is highly likely that you have discovered the optics of a hidden camera.

For example, consider a wall clock that has a domed plastic cover and a pinhole camera concealed under the numeral six on the clock face. When the SpyFinder is used to scan the clock, a reflection will be noted where the camera is located beneath the six and a reflection will also be noted from the plastic cover. However, if you move your vantage point just a little, you will notice that the location of the false positive reflection point from the plastic cover will move, while the reflection from the camera remains under the numeral six on the clock face.

A free spy camera is included with the SpyFinder to ensure that customers know how safe and effective this device is.

For more information, contact:

### M. J. ELECTRONICS

P.O. Box 212

Mt. Vernon, NY 10552

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New thermoelectric devices, prepped with a temperature cutoff switch. Originally intended for 12Vdc use in picnic and automotive coolers/ heaters.

127 thermocouples per device.  $\Delta T_{max}=79\text{degC}$ ,  $T_{hot}=50\text{degC}$ ,  $V_{max}=16.1\text{V}$ .

30MM x 30MM x 3.3MM  
 $Q_{max}=38.7\text{ Watts}$ ,  $I_{max}=3.9\text{A}$ .  
**CAT# PJT-5** **\$9<sup>75</sup>** each  
10 for \$9.00 each

40MM x 40MM x 3.8MM  
 $Q_{max}=56\text{ Watts}$ ,  $I_{max}=5.6\text{A}$   
**CAT# PJT-6** **\$12<sup>75</sup>** each  
10 for \$11.75 each

40MM x 44MM x 3.3MM  
 $Q_{max}=80.6\text{W}$ ,  $I_{max}=8.1\text{A}$   
**CAT# PJT-7** **\$14<sup>75</sup>** each  
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### 12 VDC 92 MM COOLING FAN

Papst Multifan #3312.  
3.63" square x 1.27" ball bearing cooling fan. 12 Vdc, (6-15 Vdc) 290 mA. Fiberglass reinforced plastic PBTP housing, PA impeller. 47.1 CFM. 3000 RPM.

12" 22 AWG leads. UL, CSA, CE, VDE.  
**CAT# CF-204** **\$3<sup>50</sup>** each  
10 for \$3.25 each

### 16 CHARACTER X 4 LINE LCD WITH LED BACKLIGHT

Solomon Goldentek # LM1112SYL  
Module size: 3.43" x 2.36" x 0.53"  
Viewing area: 2.43" x 1"  
Character size: 0.11" W x 0.18" H.  
5 x 7 dot character.  
LCD type: STN yellow-green.  
LED color: Yellow-green  
**CAT# LCD-108** **\$12<sup>50</sup>** each

### 3-6 VDC MINIATURE SPRING-RETURN SOLENOID

Deltrol Controls #56597-60 INT Spring-return, push-pull solenoid. 2 Ohm coil. Operates on 3-6 Vdc. Intermittent duty cycle. Metal-shielded body is 0.91" x 0.42" x 0.45" high. 0.1" diameter plunger extends 0.4" on each side of solenoid. One end of plunger has a 0.11" diameter nylon cap. Four pc pins on 0.75" x 0.2" centers.

**CAT# SOL-89** **\$1<sup>35</sup>** each  
10 for \$1.10 each

### HELICAL XENON FLASHTUBE

Heimann # AH0640EC02  
0.86" w x 1.3" h x 0.58" excluding leads. Outer leads are 1.64" long on 0.58" centers. Center wire lead.

**CAT # FLT-8** **\$3<sup>50</sup>** each  
10 for \$3.00 each

### SOLAR CELLS w/ CHARGING CIRCUIT - 3 LED'S

Here's a great start for a solar cell project. From not-yet-assembled solar-powered garden lights, these assemblies include two glass photovoltaic cells mounted on a plastic base. Output is approximately 2.6 Vdc @ 25 mA in bright sunlight. Under the photocells is a bracket for a two cell rechargeable AA pack & a small circuit board with three red LEDs. There is a photoresistor on top of the panel between the solar cells to sense light and dark conditions. In daylight the cells charge the battery. When it gets dark, the LEDs light. These are working units but the batteries packs are old and may not take a charge. Our two AA cell nickel-metal-hydrate pack, CAT# NMH-2AA (\$2.00 ea.) is a good replacement. Solar cell surface area: 3.78" X 1.98". **CAT# SPL-05**

**\$4<sup>50</sup>** each  
10 for \$4.25 each  
100 for \$4.00 each

### INVERTER FOR EL PANELS AND STRIPS

Light-Tape™ inverter designed for lighting electroluminescent strips and panels up to 1 square foot. Operates on 12 Vdc or less, depending on surface of panel.

2.35" x 1.08" x 0.68" black plastic enclosure. 18" leads with inline fuse on input. Output requires a 2-pin, 0.1" connector like our CAT# CON-230P (not included). **CAT# INV-9** **\$8<sup>95</sup>** each

### DIGITAL MULTIMETER

Right Tech 9202  
Features found on more expensive meters including LCD readout with 0.8" high digits, a transistor and diode tester and audible continuity checker. Overload protection and low battery indicator. Protective rubber jacket prevents accidental damage. Includes test leads and battery. Ranges to: 1000 Volts DC  
750 Volts AC  
10 Amps DC  
Resistance to 2000K Ohms  
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**\$3<sup>75</sup>** each  
10 for \$3.50 each  
75 for \$3.00 each

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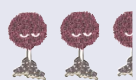


# Build a Geiger Counter — Part I

## Check for Unhealthy Levels of Radiation

### This Month's Projects

Geiger Counter . . . 36  
Your Own Casino . . 42  
Side-Scrolling LEDs . . 46



### The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

**N**ORM — or naturally occurring radioactive material — is found almost everywhere and the average person in the US is exposed to about 360 millirems of radiation from natural sources each year. A millirem — or 0.001 of a rem — is a measure of radiation exposure and more than 80 percent of this exposure level comes from background radiation sources. For example, consumer products contribute 10 millirem/year, while living or working in a brick building can add another 70 millirem/year. On the extreme, a person who smokes 1.5 packs of cigarettes each day increases his or her exposure by 8,000 millirem/year.

A Geiger counter produces an audible click and blinks an LED each time it detects a radioactive particle. Typically, the counter clicks 10-20 times a minute due to normal background radiation (which is less than 80 millirem/hr) and — although the device is sensitive enough to measure background radiation — it is not suitable for measuring radon gas. Radon is a colorless, tasteless gas that also comes from uranium and is found in many rocks and soil, especially soil that has been contaminated with pollution. It's natural-

ly found in the air we breathe, but is harmless because it is so diluted that we don't notice it. There are radon gas detectors that use an activated charcoal filter that are easy to use and more accurate.

Radioactivity is the spontaneous emission of energy from the nucleus of certain atoms. The most familiar radioactive material is uranium, although there are many other kinds.

There are three forms of energy associated with radioactivity: alpha, beta, and gamma radiation, and the classifications are determined according to the penetrating power of the radiation (Figure 1). Our Geiger counter can detect all three types of radiation.

Alpha rays are the nuclei of helium atoms: two protons and two neutrons bound together, giving alpha rays a net positive charge. Alpha particles have weak penetrating ability, and a couple of inches of air or a few sheets of paper can effectively block them.

Beta rays are found to be electrons, identical to the electrons found in atoms. Beta rays have a net negative charge and a greater penetrating power than alpha rays, going through approximately three mm of aluminum.

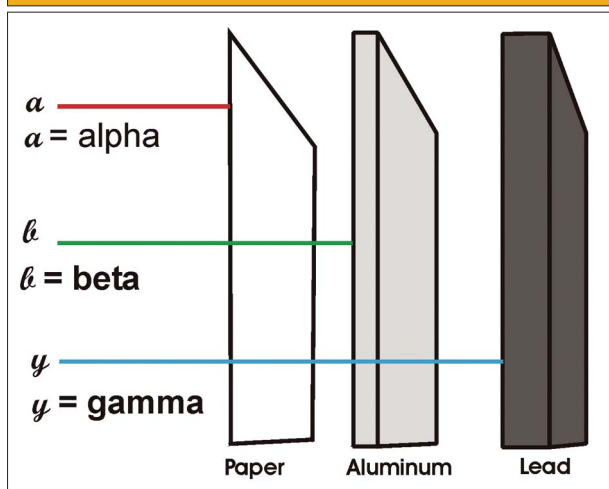
Gamma rays are high energy photons. They have the greatest penetrating power and are able to pass through several centimeters of lead and still be detected on the other side. Thick lead is needed to attenuate gamma radiation.

On the following pages we will build a fully functioning basic Geiger counter, and in the next issue, we will enhance our Geiger counter by adding either an analog meter or a digital meter and a suitable serial port to connect to a Windows-based PC. The Windows 98/XP program is free and available for downloading.

### Geiger-Müller Tube

Originally designed by Hans Geiger and Walther Müller in 1928, Geiger-

Figure 1. Penetration strength of radiation.



Müller tubes are simple devices that detect and measure radioactivity, and the technology hasn't changed very much.

Shown in a cutaway drawing of a typical Geiger-Müller (G-M) tube in Figure 2, the wall of the GM tube is a thin metal (cathode) cylinder surrounding a center electrode (anode). The metal wall of the G-M tube serves as the cathode of the G-M tube. The front of the tube is a thin mica window sealed to the metal cylinder. This window allows the passage and detection of the weak penetrating alpha particles. The G-M tube is first evacuated then filled with neon, argon, and halogen gas.

Our G-M tube is put into an initial state (ready to detect a radioactive particle) by applying a +500-volt potential to the anode (center electrode) through a 10 MΩ current-limiting resistor. A 470K ohm resistor is connected to the metal wall cathode of the tube and to a ground. The top of the 470K ohm resistor is where we see our pulse signal whenever a radioactive particle is detected.

In this initial state, the G-M tube has a very high resistance. However, when a radioactive particle passes through the G-M tube, it ionizes the gas molecules in its path and creates a momentary conductive path in the gas. This is analogous to the vapor trail left in a cloud chamber by a particle. In the G-M tube, the electron liberated from the atom by the particle and the positive ionized atom both move rapidly toward the high potential electrodes of the G-M tube. In doing so, they collide with and ionize other gas atoms, creating a momentary avalanche of ionized gas molecules. These ionized molecules create a small conduction path, allowing a momentary pulse of electric current to pass through the tube, permitting us to detect the particle.

This momentary pulse of current appears as a small voltage pulse across the 470K ohm resistor. The halogen gas quickly quenches the ionization and the G-M tube returns to its high resistance state ready to detect more radioactivity.

## Dead Time

For the short amount of time when the G-M tube is detecting one particle, another radioactive particle that enters the tube will not be detected. This is called dead time. The maximum dead time for our G-M tube is 90 microseconds (or 0.00009 seconds). There is a mathematical formula for adjusting a Geiger counter readout to compensate for the G-M tube's dead time, but the adjustment is so small that — for practical applications — it can be ignored. On a professional level, high end nuclear work will take a tube's dead time into consideration.

## Count Rate Vs. Dose Rate

Each output pulse from the G-M tube is a count. The counts-per-second give an approximation of the strength of the radiation field. The G-M tube has been calibrated

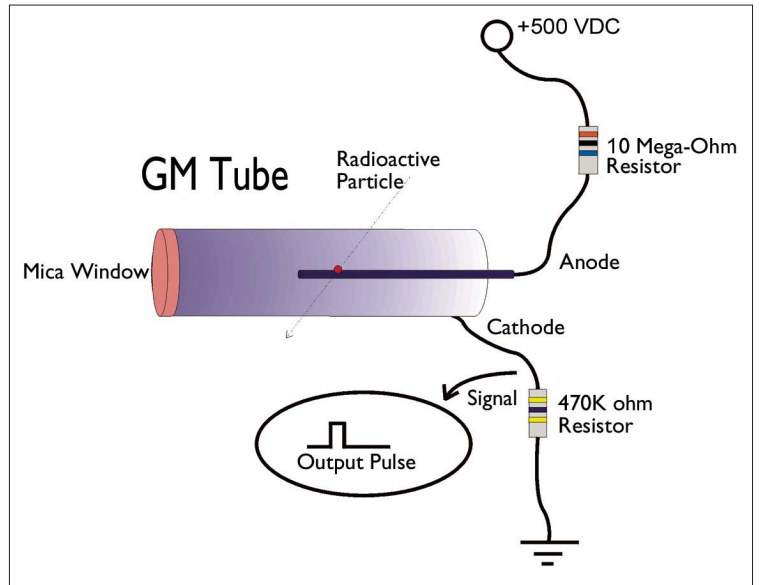


Figure 2. Cross-section and function of typical Geiger-Müller tube.

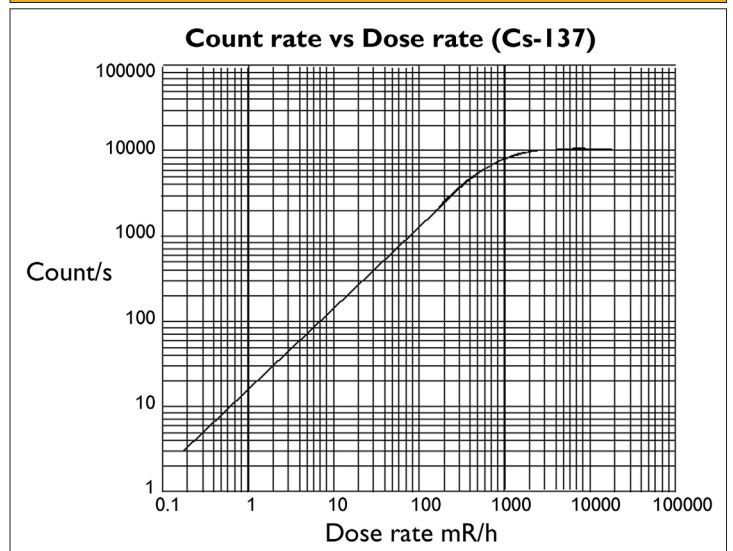
using a cesium-137. The chart is shown in Figure 3.

## Schematic

The circuit is shown in Figure 4. The 4049 Hex Inverting Buffer is set up as a square wave generator. The power MOSFET IRF830 switches on and off the current to the primary windings of the mini step-up transformer. The output of the mini step-up transformer is fed to a voltage doubler, consisting of two high voltage diodes — D2 and D3 — and two high voltage capacitors — C4 and C5.

The high voltage output from this stage is regulated to the 500 volts needed for our G-M tube by three zener diodes stacked one on top of the other (D4, D5, and D6). Diodes D5 and D6 are 200-volt zener diodes and diode D4

Figure 3. Chart detailing count rate vs. dose rate (in millirem/hr).





is a 100-volt zener. Together, they equal 500 volts, which is the optimum operating voltage for our G-M tube.

The 500-volt, regulated output is fed to the anode of the G-M tube through a current-limiting, 10-M $\Omega$  resistor, R4. The 10-M $\Omega$  resistor limits the current through the G-M tube and helps quench the avalanched ionization when a radioactive particle is detected.

The cathode of the tube is connected to a 470K-ohm resistor (R5). The voltage pulse across R5 generated by the detection of radiation feeds to the base of a 2N3904 NPN transistor through a one  $\mu$ F capacitor (C6).

The NPN transistor clamps the output pulse from the GM tube to Vcc and feeds it to an inverting gate on the 4049. The inverted pulse signal from the gate is a trigger to the 555 timer, which is set up in monostable mode that stretches out the pulse received on its trigger. The output pulse from the timer flashes the LED and outputs an audible click to the speaker via pin 3.

## Construction

You can hard-wire this circuit to a breadboard or use the available PCB (printed circuit board). Although you do not need the PCB, it will make construction easier. The top silk screen of the PCB is shown in Figure 5. Begin construction by wiring the square-wave generator and pulse-shaping circuit using the 4049. Solder the 16-pin IC socket for the 4049 and place and solder components R1, R2, R3, C1, C2, and D1. R1 is a 4.3-K $\Omega$  resistor with yel-

low, orange, and red bands. R2 is a 15-K $\Omega$  resistor with brown, green, and orange bands. R3 is a 5.6-K $\Omega$  resistor with green, blue, and red bands.

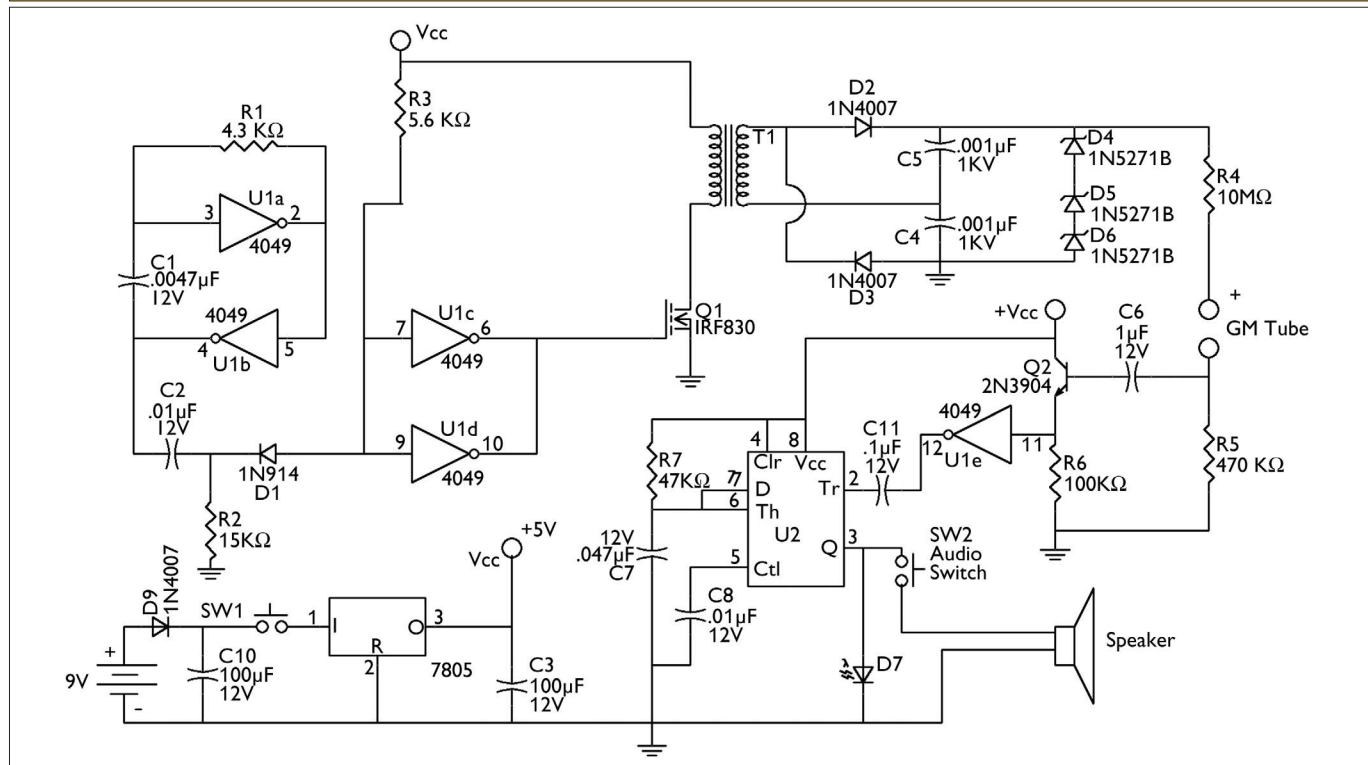
Now, construct the high voltage section, consisting of the step-up transformer T1; IRF830 transistor Q1; diodes D2, D3; and capacitors C3, C4, and C5. To this, add the five-volt 7805 regulator Q3 and capacitor C10. Place and solder the nine-volt battery terminals on the PC board and diode D9 (1N4007). Connect the SW1 power switch using six-inch-long wire leads. Insert the 4049 IC into the 16-pin IC socket soldered to the PC board.

## Testing HV Section

**CAUTION:** This circuit generates high voltage power that can provide an electrical shock. Exercise caution when working around the high voltage section of the circuit. The capacitors C4 and C5 can hold a high voltage charge long after the circuit has been shut off and can still provide an electrical shock. If you are uncomfortable working with high voltage, you can skip the high voltage testing section.

At this point in the construction, you should check the high voltage power supply by following this procedure: Turn the SW1 power switch to off. Insert the nine-volt battery onto the PC board. Set up a VOM to read 500 to 1,000 volts. Place the positive lead of the VOM at the junction of C4 and D2 and the negative lead of the VOM to the “-” (neg-

Figure 4. Circuit schematic.



ative) terminal of the nine-volt battery.

Apply power to the circuit using SW1 as shown in Figure 6. The circuit should generate anywhere between 550 and 800 volts, depending upon component tolerances. If you are reading between 550 and 800 volts, fine; turn off the power, and add the three zener diodes (D4, D5, and D6) used for voltage regulation. Apply power again with the positive lead of the VOM still attached to the junction of C4 and D2 and you should read a voltage of 500 volts. If you're not getting a proper voltage reading, check the zener diodes to make sure you have them orientated in the right direction.

## Continuing Construction

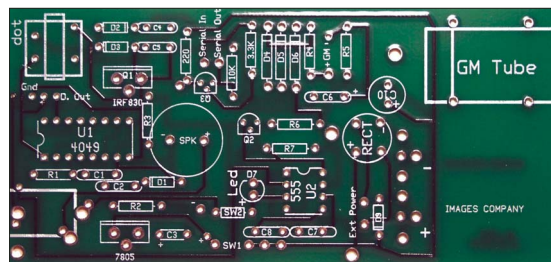
Finish the construction of the circuit by adding the 555 timer, capacitor C6, resistors, and transistor. Mount and solder resistors R4 (10 M $\Omega$  with bands of brown, black, and blue), R5 (470 K $\Omega$  with bands of yellow, violet, and yellow), R6 (100 K $\Omega$  with bands of brown, black, and yellow) and R7 (47 K $\Omega$  with bands of yellow, violet, and orange).

## Attaching the G-M Tube

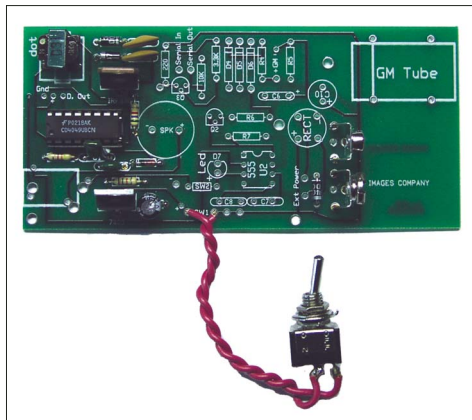
The Geiger-Müller tube has two leads. The lead connected to the metal sides of the tube is the ground. This is soldered to the (-) G-M terminal on the PC board (Figure 7). The center terminal of the GM tube has a removable solder lead. Remove the lead, solder 1.5 inches of wire to it and reattach the lead to the center terminal of the G-M tube. Take the opposite end of the wire and solder it to the (+) G-M terminal on the PCB.

The Geiger-Müller tube is delicate and should be protected in an enclosure. You should face the G-M tube toward a 1/2 inch hole in the enclosure that allows the front surface (mica window) of the G-M tube to remain exposed. This way, alpha particles can pass through the thin mica window and be detected.

Mount the G-M tube to the PC board using a scrap of wire. The G-M tube is positioned above the G-M tube's silk-screened outline on the PCB. One end of the wire is soldered into one of the side holes, and the other wire is looped over the G-M tube and soldered into the second hole





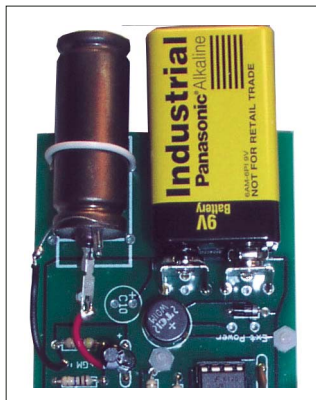


**Figure 6.** Circuit board ready for HV test.

on the opposite side. Keep the wire snug when soldering it into the second hole. After securing the tube with the wire, a small amount of glue or epoxy can be dabbed on the wire tube assembly for added support.

## Radioactive Sources

Uranium ore is available from a number of sources,



**Figure 7.** Detail showing G-M tube secured on PCB.

including eBay, but a more reliable solution is purchasing a radioactive source. Small amounts of radioactive materials are available for sale, encased in one-inch diameter by 1/4-inch thick plastic disks. The disks are available to the general public — license exempt — and the material outputs radiation in the microcurie range deemed by the Federal government as safe. The cesium-137 is a good gamma ray source. Cesium-137 has a half-life of 30 years.

## Check Out

Background radiation from natural sources on Earth and cosmic rays in the atmosphere will cause the Geiger counter to click. In my corner of the world, I have background radiation that triggers the counter 12-20 times a minute. Turn on your Geiger counter. If you have a radiation source, bring it very close to the GM tube, and the radiation will cause the counter to start clicking more frequently. The LED will pulse with each click, which represents the detection of one of the radioactive rays: alpha, beta, or gamma. **NV**

## Parts List

Below is the complete parts list (including case), available as the GCK-02 kit for \$149.95 from Images SI, Inc.

GM	Geiger-Müller tube
T1	HV mini step-up transformer
C1	0.0047 $\mu$ F capacitor
C2	0.01 $\mu$ F capacitor
C3,C10	100 $\mu$ F capacitor
C4,C5	0.01 $\mu$ F 1 KV capacitors
C6	1.0 $\mu$ F 12 V capacitor
C7	0.047 $\mu$ F capacitor
C8	0.01 $\mu$ F capacitor (16 V)
D1	1N914 diode (or equiv.)
D2,D3,D9	1N4007 1 KV diodes
D4	1N5271 100 V zener diode
D5,D6	1N5281 200 V zener diode
D7	Red LED chrome case with mounting hardware
SPK	Speaker
R1	4.3 K $\Omega$ , 1/4 watt resistor
R2	15 K $\Omega$ , 1/4 watt resistor
R3	5.6 K $\Omega$ , 1/4 watt resistor
R4	10 M $\Omega$ , 1/4 watt resistor
R5	470 K $\Omega$ , 1/4 watt resistor
R6	100 K $\Omega$ , 1/4 watt resistor
R7	47 K $\Omega$ , 1/4 watt resistor
SW1	Panel mounted On/Off switch
SW2	Panel mounted On/Off switch
U1	4049 Hex Inverting Buffer
U2	555 timer
U3	7805 voltage regulator
Q1	IRF830 MOSFET transistor

Q2	2N3904 NPN transistor
2	9-V battery terminals, PC mount (PCB only)
1	470 $\Omega$ , 1/4 watt resistor (for optional headphones)
3	3.5 mm jacks (For additional options: head phones, digital out, external power supply)
1	Nylon screw and nut (2-56) for mounting PCB to enclosure)

Misc.: Case, LED holder, LED cable, On/Off switch, 9V battery cap, Geiger counter case

GCK-02: Complete Geiger Counter Kit (all components) \$149.95

Components that are sold separately:

G-M tube	\$ 54.95
Mini step-up transformer	\$ 12.00
Geiger counter PCB	\$ 10.00

Radioactive Sources:

Uranium Ore	\$12.00
CS-137 source	\$84.00 — Drop shipped from different location

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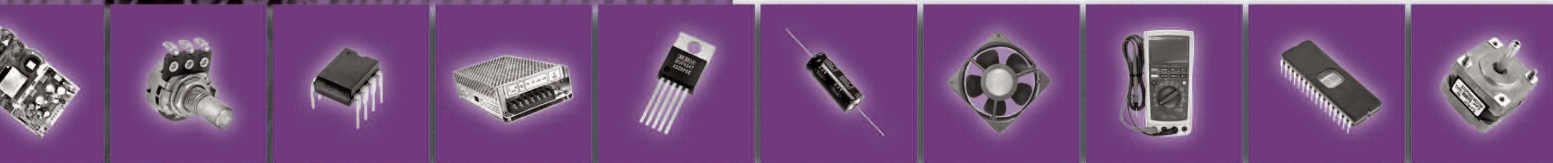
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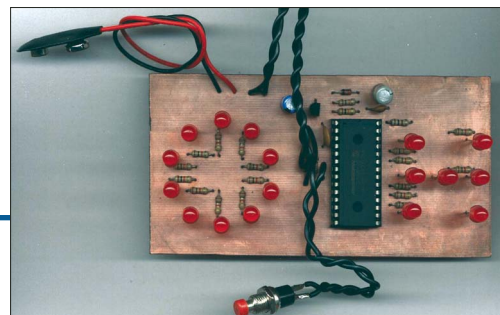
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# Start Your Own Casino

## This Roulette/Dice Project Is a Sure-Bet for Beginners



**T**here is no doubt that Microchip microcontrollers are very popular among the hobbyists and experimenters who are using them for many interesting applications. There are several Microchip microcontroller families, but for the beginner, it is advisable to use a device with an easy learning curve.

Although the PIC16C5X family does not have some of the advanced features — such as A/D converters or dedicated serial ports — the low cost of these microcontrollers and their simplicity of use make them ideal for those who are new to microcontrollers. If you already are planning to experiment with these microcontrollers, maybe you are looking for a very simple circuit to try out for your first microcontroller project.

Beginners should start out with a very simple test program. This is to insure the first correct results and to let the experimenter know more about several aspects that may cause confusion, like the reset signal, effects of different oscillator types, considerations about input/output pins, etc. The majority of these test programs only contain a very simple code that executes elemental tasks like outputting a pulse train on a pin or blinking LEDs. You may realize that, although these test programs are useful for learning how to program your first microcontroller, there is no practical use for the micro once this is done, especially if you used an OTP (One Time Programmable) chip. On the other hand, starting out with an advanced program or a complex circuit with a lot of components may result in failure of the project and the resulting frustration.

This project provides an intermediate point between these two extreme situations, with the help of a very simple circuit for your first microcontroller project. It also has the advantage of being useful and fun. Here, you'll learn how to build an electronic roulette/dice using a microcontroller. The project is easy to build and many of the parts — like the resistors and LEDs — may be in your junk box already. Moreover, once the circuit has been finished, it can be used in games or as a gift for kids. Fans of kits surely will enjoy the roulette and dice circuits combined in one unit, because vendors offer these circuits as separate kits.

### Practical Considerations

The PIC16C55 microcontroller was chosen mainly

because of its 20 I/O

lines that allow us to implement our project using only two ICs: the microcontroller and a voltage regulator. Of course, in a microcontroller with fewer I/O pins (like the 16C54), you can use the same input/output pins for several different tasks by multiplexing them.

There are four variations of the 16C55, depending on the oscillator type to be used. The XT and HS versions of these microcontrollers are designed to be used with a crystal or resonator, so you can use them for applications where the timing is critical and important. The LP version is intended for low power applications, while the RC version can operate with only a resistor and a capacitor to generate the clock signal required. Keep in mind that the resistor and capacitor tolerances — along with the operating temperature — will affect the oscillation frequency in RC mode, so this oscillator type is to be used only in circuits with timing insensitive processes.

It is important to note that these oscillator types are pre-configured at the factory in the OTP parts, so you must use them only with the specified oscillator configuration. On the other hand, in the UV erasable version (the /JW window parts), any of the four different oscillator types can be selected during programming. Thus, if you plan to do a lot of experimenting with the 16C55, you may consider buying a 16C55/JW part, which can be erased with an EEPROM eraser and reprogrammed again. When your code is usable and free of errors, you can program it to be a low cost OTP part.

Since the electronic roulette/dice project is basically a game, we decided to use a 16C55-RC part. That will allow beginners to build the circuit without worrying about crystal selection or drive level considerations.

### Software

To simulate the action of a pseudo random number generator, we are using a variable as a high speed counter. Because this counter increments itself very quickly, its value in a determined time is practically unpredictable. As a result, we can use this value as a random number. This variable is used to count from 1 to 30 and then starts over again from one. This counting is executed until the user

presses the "ROLL" push-button switch. When this happens, the program tests the status of the "ROULETTE/DICE" switch and jumps to the respective section of code. Because the counter has a maximum value of 30, it is possible to generate the necessary final numbers for the roulette and the dice from the same counter. To accomplish this, we can successively subtract a value of 10 from the counter to obtain a final value between one and 10 to be used for the roulette.

In a similar way, a value of six is successively subtracted from the counter to obtain a value ranging from one to six when the dice are selected. If the roulette has been selected, the LEDs will "spin" 17 times, using different speeds to simulate the effect of a ball spinning around numbers. Finally, the roulette wheel will spin one more time and indicate the final winning number by blinking a corresponding LED.

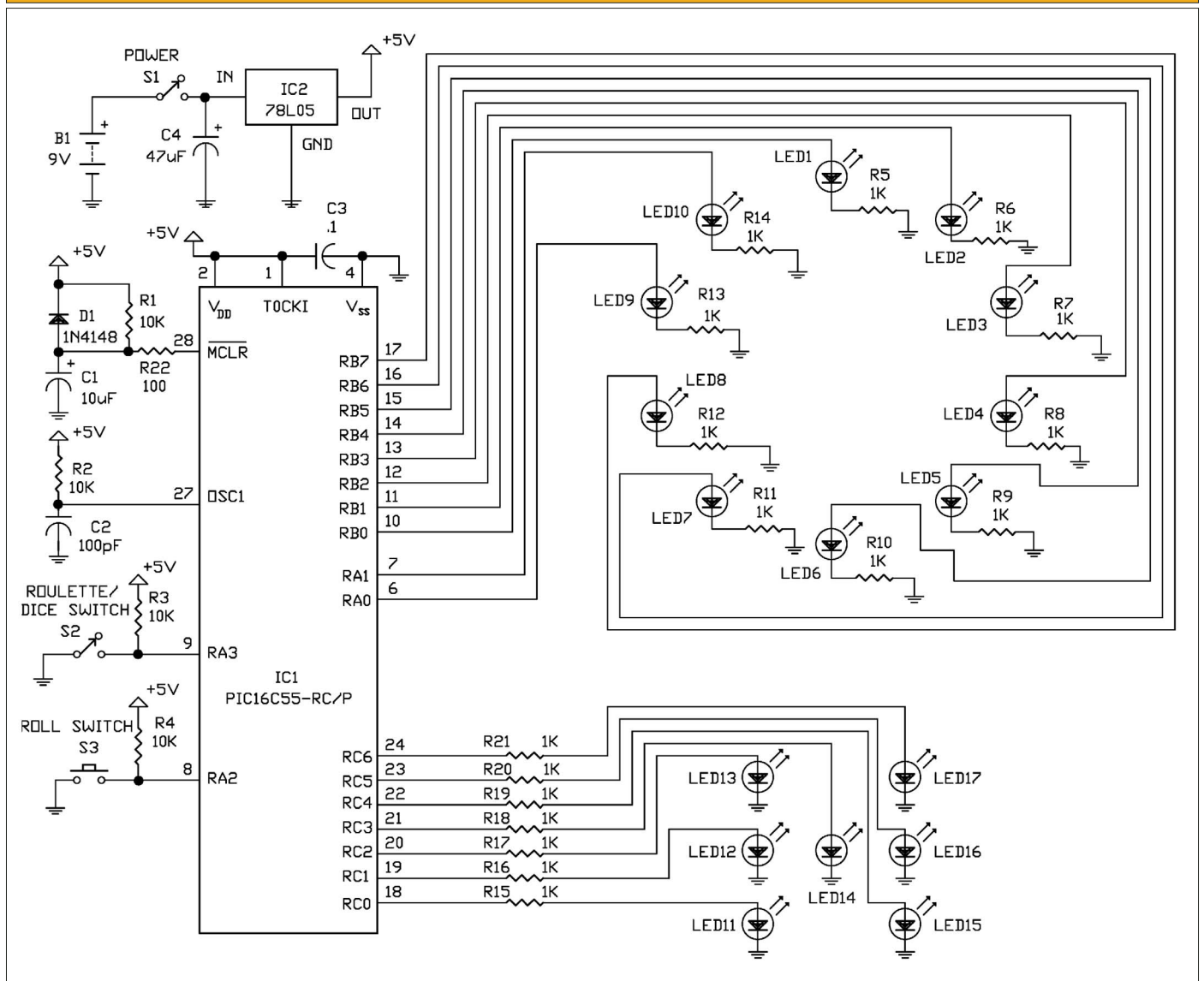
A similar process is used when the dice mode is selected. In this case, the dice will "roll" eight times, slowing the

speed in each roll. The dice will roll one more time and then stop to blink the final winner number. Immediately after that, the high-speed counter begins to count again until another press of the ROLL push-button switch.

## Circuit Description

Figure 1 shows the schematic of the electronic roulette/dice. Two I/O pins of the microcontroller are configured as inputs for sensing the switches, while the rest are used to drive a corresponding LED. Only I/O pin RC7 is not used. An external power-on reset is provided by R1, D1, and C1. R2 and C2 form the RC combination necessary to generate the internal clock signal. The "ROULETTE/DICE" select switch, S2, and the "ROLL" push-button switch, S3, are assigned to the RA3 and RA2 pins of PORTA, respectively. I/O port PORTC is used

Figure 1. Schematic.





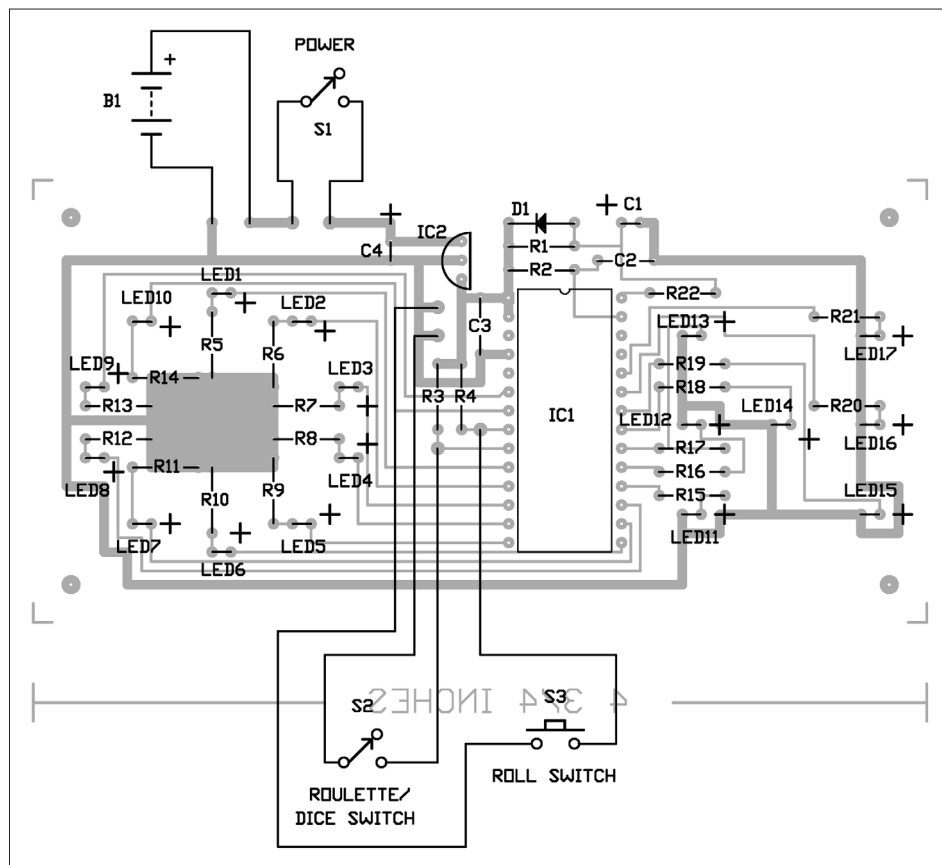


Figure 2. Parts Placement.

exclusively to drive the dice's LEDs.

The roulette's LEDs are driven by the entire PORTB and the two RA0 and RA1 pins of PORTA. The current for each LED is about three mA, for a 1.7 volt voltage drop in the red LEDs. To make the unit portable, a nine-volt battery is used to power the circuit. Then, voltage regulator IC2 produces the five volts required for the microcontroller.

As you can see, the advantage of using a microcontroller with the sufficient number of I/O lines gives us the

that the leads of the LEDs should be high enough over the rest of the components to enable proper installation of the board in the case. Next, install all of the switches with their proper connections to the PC board. In our project, the switches were mounted on the top panel of the plastic case.

You must program your microcontroller chip using the ROU\_DICE.HEX file (also available on the *Nuts & Volts* website). This file is in the INHX8M format, which is accepted by most programmers. If you do not have access to a PIC programmer, look for electronic shops in your area that may have this service for a low fee. Finally, install IC1 and the nine-volt battery connector. All the normal precautions for static electricity should be observed when handling the PIC. Before using the unit, inspect it carefully for solder bridges, loose connections, and improperly installed components.

## Operation

To test the unit, connect the nine-volt battery and turn on switch S1. As a start-up, the roulette will spin one time and the first LED will remain on. Also, the dice will indicate the number 1. If this does not happen, then you have a circuit problem. Use the following guide to find the cause of the problem: When you connect a voltmeter from ground to pin 2 of IC1, a five volt ( $\pm 10$  percent) reading should be present.

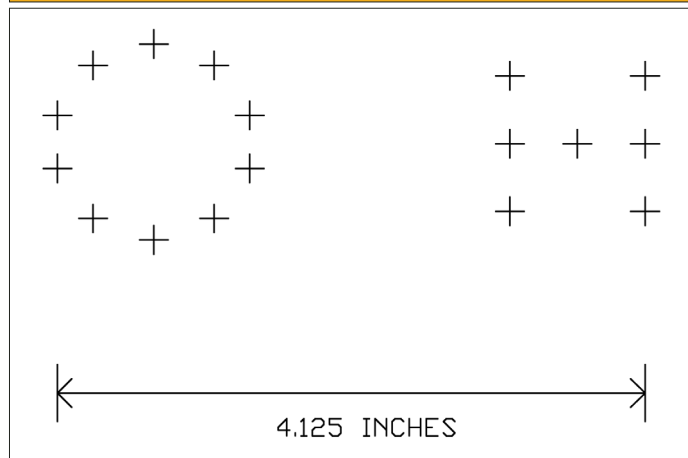
opportunity to do a simple and straightforward design. In this particular case, each I/O line is assigned either to drive an LED or to sense a switch.

## Construction

The circuit is assembled on a printed circuit board. The foil pattern is available online from the *Nuts & Volts* website at [www.nutsvolts.com](http://www.nutsvolts.com). The parts placement diagram for that PC board is shown in Figure 2. Begin construction by installing all of the resistors. Next, install diode D1 and the electrolytic capacitors, observing the proper polarity for all of them. Then, install the remaining capacitors and a socket for IC1. Voltage regulator IC2 must be installed with the correct orientation.

Install all of the LEDs, observing their correct polarity. For a pleasant, uniform brightness, all of the LEDs should be of the same type. A plastic case is a good choice to house the circuit and you can use the template provided in Figure 4 as a drilling guide for the LEDs. Note

Figure 3. Drill Template.



# Build an Electronic Roulette Wheel/Dice

If not, check the voltage at the battery terminals.

If you have a scope or a frequency meter, check for a nearly 170 kHz clock signal at pin 26 of IC1. That frequency is actually the internal oscillator frequency, divided by four (in RC mode only). Do not expect to read that exact frequency in your meter. The RC oscillator frequency is independent of the temperature, supply voltage, and resistor and capacitor tolerances, so you can read a very broad range of values. The important point is to verify that the microcontroller is really oscillating.

If this does not help, maybe you have a problem with the reset signal. With power applied, temporarily short circuit the terminals of capacitor C1. The microcontroller should restart operation properly after each resetting. If all of this fails, maybe you have a defective or improperly programmed microcontroller.

If everything is working, set switch S2 to "ROULETTE" and press the "ROLL" push-button switch, S3. You should see the roulette "spinning" and then slowing down to indicate the winning number. To start another play, press switch S3 again. Then set switch S2 to "DICE" and press switch S3. The dice game should function correctly. If you detect any problems, go over your work carefully to find the cause of the problem.

## Final Comments

Often, when you begin to experiment with microcontrollers, it is good to use a simple device, with only the necessary amount of memory and a basic set of registers that you can easily understand. The PIC16C5X family satisfies these requirements for beginners, and as your experience increases, you can then try more advanced devices. Better yet, you could try to get the most of these microcontrollers by learning how to use their peripheral features, like the

real time clock/counter or the watchdog timer.

Although the PIC16C5X family is easy to use, that does not mean that they are not powerful. In fact, many industrial and advanced applications are using these types of microcontrollers. Moreover, the mid-range and high-end Microchip families are basically enhanced versions of the PIC16C5X architecture, so this family provides an excellent starting point for learning PIC programming. **NV**

## Parts List

### Resistors

(All resistors are 1/4 watt, five percent units, unless otherwise noted.)

R1-R4 — 10,000  $\Omega$

R5-R21 — 1,000  $\Omega$

R22 — 100  $\Omega$

### Capacitors

C1 — 10  $\mu$ F, 16 volts, electrolytic

C2 — 100 pF, ceramic disc

C3 — 0.1  $\mu$ F, ceramic disc

C4 — 47  $\mu$ F, 16 volts, electrolytic

### Semiconductors

IC1 — PIC16C55 RC/P Microchip microcontroller

IC2 — 78L05 five-volt, 0.1-amp, fixed-voltage regulator

D1 — 1N4148 diode

LED1-LED17 — LED (red)

### Other components

S1, S2 — SPST switch

S3 — Normally-open, push-button switch

B1 — Nine-volt battery

**Miscellaneous:** Nine-volt battery connector, 28-pin IC socket, case, solder, hardware, cable, wire, printed circuit materials, etc.

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# Side-Scrolling LED Display

## Constructing a Side-Scrolling LED Stock Ticker Controlled by a Repurposed Gameboy

The Nintendo Gameboy™ is one of the most ubiquitous gaming devices around. It has pretty much dominated the handheld gaming market since its inception in the late 80s. However, with the recent release of the new Nintendo DS, a lot of old Gameboys have become obsolete and abandoned. Consequently, I urge hobbyists and embedded systems developers to try their hand at programming and building electronics focusing on the Gameboy, as all of those old Gameboys lying around are not just toys but are actually decent embedded devices.

For this article, I will discuss an electronics project that uses an old Gameboy Color as a microcontroller to drive and control the side-scrolling LED stock ticker shown in Figures 1 and 2. The LED stock ticker consists of 105 x 7 dot matrix LEDs that are cascaded into a 50 x 7 LED screen. The whole project is wire-wrapped and running at a frequency much less than eight MHz.

The Gameboy has a Zilog Z80-like microprocessor inside. It has eight Kb of internal RAM, eight Kb of video RAM, and a 160 x 144 LCD screen, all of which make it an interesting embedded development platform. Since this is an electronics interfacing project, I will not be using much of the Gameboy's built-in LCD screen except for status display. Instead, I will be using the Gameboy's synchronous serial connector to interface

with external electronics.

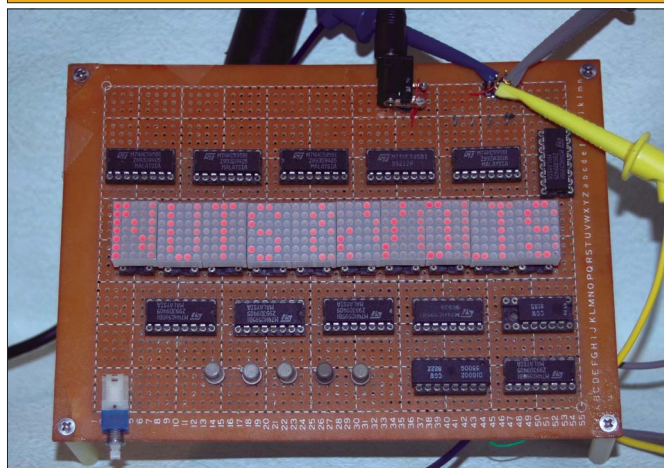
### The Underground Internet Gameboy Development Community

An underground community of Gameboy hobbyists has been in existence since the mid-90s. This community has reverse-engineered the technical specifications of the Gameboy and made it easy to develop hardware and software for the Gameboy. Jeff Frohwein's website [www.devrs.com](http://www.devrs.com) is probably the best starting point for a would-be Gameboy developer. The internal architecture of the Gameboy is well-documented, and I highly recommend "Everything You Always Wanted to Know About Gameboy." Available on the Internet at [www.devrs.com/gb/files/gbspec.txt](http://www.devrs.com/gb/files/gbspec.txt) it offers a technical overview of the Gameboy and a whole slew of free and powerful development tools that exist for the Gameboy. For this project, I used the GBDK C compiler suite for software development, available at <http://gbdk.sourceforge.net>

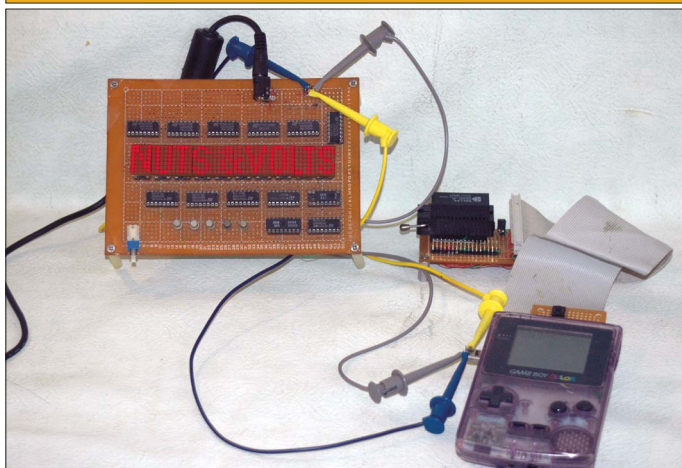
### Gutting a Gameboy Cartridge

In order to write software that will run on a Gameboy, one has to make his own cartridge. This can

**Figure 1.** The LED stock ticker consists of 105 x 7 dot matrix LEDs which are cascaded into a 50 x 7 LED screen.



**Figure 2.** An underground community of Gameboy hobbyists has been in existence since the mid-90s.



be done by gutting out an existing cartridge and connecting your own EPROM or EEPROM into the printed circuit board of the old cartridge. The connectors of a Gameboy cartridge are basically address and data bus lines to external ROM. For more details, [www.devrs.com/gb/files/gameboy3.gif](http://www.devrs.com/gb/files/gameboy3.gif) shows a schematic diagram of how to connect a custom EEPROM to the Gameboy. However, getting into the details of building your own homemade cartridge is probably an article by itself, so I won't discuss it any further.

## The Serial Connection of the Gameboy

The Gameboy has a synchronous serial interface that was intended for multiplayer use. This serial interface, however, is quite sophisticated and can be used for other I/O operations. In the case of this project, the serial interface is used to drive shift registers, which, in turn, drive a dot matrix LED display. The Gameboy serial interface is actually quite similar to the standard SPI (serial peripheral interface) used by many microcontrollers. The interface consists of three pins: clock signal, data in, and data out. For this project, we will only use the clock and data out signal. The Gameboy will not be receiving data from the outside. That is, the LED display will not be sending information back to the Gameboy. For more details on the Gameboy serial interface, check out [www.devrs.com/gb/files/gblpof.gif](http://www.devrs.com/gb/files/gblpof.gif)

## 74HC595 Shift Registers That Convert Serial Input to Parallel Output

Driving 350 LEDs requires a lot of output ports to individually turn on or turn off each LED. Unfortunately, the

### The Gameboy Family

*The Gameboy is actually a family of devices that come in different flavors and capabilities. Throughout the years, the Gameboy has become more refined and powerful. For this project, a Gameboy Color is needed because of its enhanced serial capabilities. The Gameboy Advance is backward compatible with the Gameboy Color, so it can also be used for this project.*

#### The Gameboy Family:

- Original Gameboy
- Gameboy Color
- Gameboy Pocket
- Gameboy Advance

Gameboy only has a serial port for I/O. Fortunately, converting a single serial output to multiple output ports is not that difficult. All we need is a standard SSI shift register chip with serial input and parallel outputs. The 74HC595 is perfect for this job. By cascading several 74HC595s in a daisy-chain fashion, we are able to have as many output ports as we want. Figure 3 shows a daisy-chained 74HC595 configuration.

## Driving Dot Matrix LED Arrays

It is conceptually simple to selectively turn on or turn off an LED using an output pin. This is exactly what we will do with our shift register outputs, as Figure 4 shows a basic element of our side-scrolling display. The D flip-flops are bit constituents of the 74HC595 shift register. Note that typical electronic designs use one flip-flop to drive one LED, but for reasons to be explained later, we actually use two flip-flops to drive an LED in this project. One flip-flop is connected to the base of a switching transistor, and another flip-flop is connected to the cathode of an LED. We will call these two flip-flops column-select flip-flop and row-value flip-flop, respectively. The column-select flip-flop

Figure 3. The daisy-chained 74HC595 configuration.

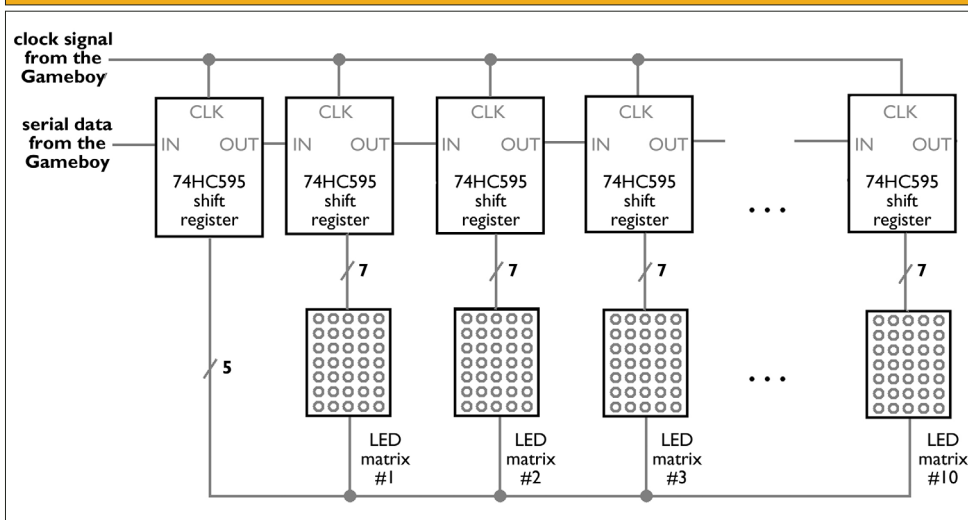
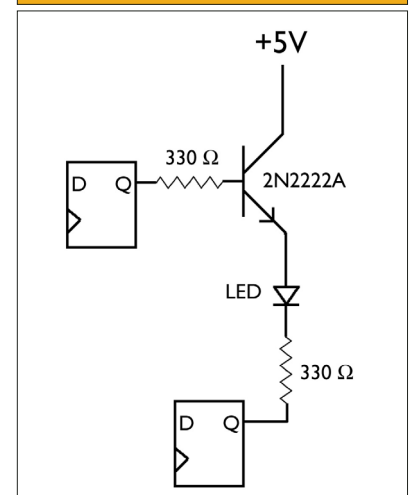
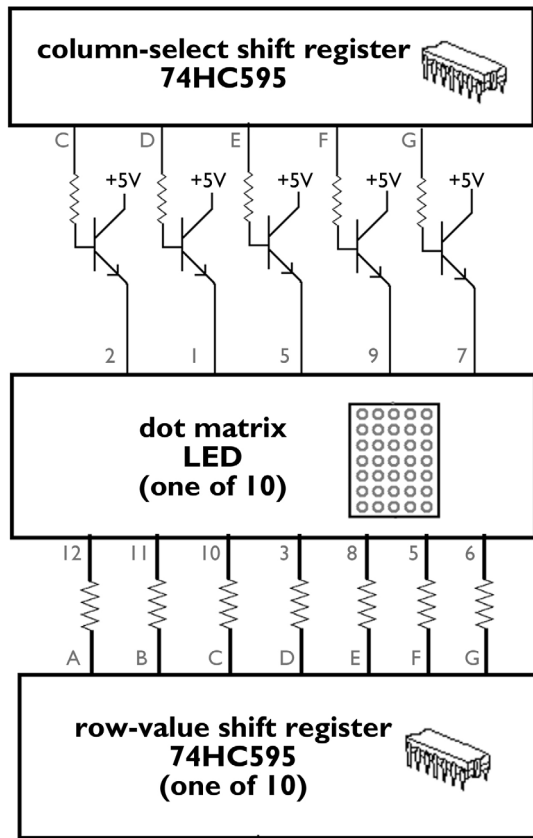


Figure 4. The basic elements of a side-scrolling display.







**Figure 5.** The hardware schematic for driving a single 5 x 7 LED component using a column-select shift register and a row-value shift register.

## Listing 1

```
disable_interrupts();
while(1) {
    delay(cycleDelay);
    sendByte(messagePointer[0+state]);
    sendByte(messagePointer[5+state]);
    sendByte(messagePointer[10+state]);
    sendByte(messagePointer[15+state]);
    sendByte(messagePointer[20+state]);

    sendByte(messagePointer[25+state]);
    sendByte(messagePointer[30+state]);
    sendByte(messagePointer[35+state]);
    sendByte(messagePointer[40+state]);
    sendByte(messagePointer[45+state]);
    sendByte(sink);
    sink = sink>>1;
    state++;
    if (sink==0x04) {
        sink = 0x80;
        state = 0x0;
    }
    if (state==6) {
        state = 0x0;
    }

    if (joypad() == J_START) {
        break;
    }
}

enable_interrupts();
sendByte(0x0);
```

is like an enable switch for the LED, while the row-value flip-flop decides whether an LED is on or off. By repeating this basic configuration, we can achieve a dot matrix display.

The LED component we use for this project is a typical 5 x 7 dot matrix LED (Jameco part #118906EX). This component has 12 input pins and 35 LEDs, but before we proceed, let's pause for a moment and give the previous statement additional thought. How can we drive 35 individually selectable LED outputs with just 12 inputs? Surely we can't produce every possible on/off configuration of 35 LEDs with just 12 pins. There is even a mathematical theorem that states this is impossible. It is called the Pigeonhole Principle in Combinatorics. But as you all know, we hardware hackers won't let a simple theorem get in the way of crafting an electronics project. We will employ a simple trick to get around this problem.

Instead of producing all possible on/off configurations of the dot matrix LED component, we can just do it one column at a time on the dot matrix, and then time-multiplex the display. In other words, we'll follow the trick done on CRT displays where electron guns drive the screen one scanline at a time but do it fast enough (approximately 60 Hz) so that our eyes can be deceived into thinking we're seeing a single solid image. That's why we need two flip-flops in the basic configuration. The column-select flip-flop is used for selecting one of the five possible columns of the 5 x 7 LED component, and the row-value flip-flop determines the on/off state of each of the LEDs in a column. Figure 5 shows the hardware schematic for driving a single 5 x 7 LED component using a column-select shift register and a row-value shift register.

Since we are doing time-multiplexing in driving the dot matrix LED, it is important to note that the display is not statically driven by the Gameboy. The Gameboy is continuously busy refreshing the LEDs. In order to show a bitmap pattern on the dot matrix display, the Gameboy has to periodically execute code and feed data to the shift registers, which, in turn, drive the LEDs.

## Hardware Architecture of the 50 x 7 Side-scrolling Stock Ticker

Using 10 of the 5 x 7 dot matrix LED components, we are able to create a 50 x 7 side-scrolling stock ticker. Each of the dot matrix LED components is controlled by a single 74HC595 shift register. By daisy-chaining 10 shift registers, we are able to control the whole 50 x 7 side-scrolling stock ticker. There is an extra shift register used for column-select, so there are effectively 11 shift registers used in this project. Please refer to Figure 3 to see the full hardware layout of the side-scrolling stock ticker.

So the Gameboy can continuously sends serial data to the 11 shift registers at 64 KB/s, the internal serial

## Parts List

All of the parts for this project (except the Gameboy) are readily available from Jameco Electronics ([www.jameco.com](http://www.jameco.com)). Some of the parts are also available from HSC Electronic Supply ([www.halted.com](http://www.halted.com)). Used Gameboy handhelds can be purchased from Gamestop stores ([www.gamestop.com](http://www.gamestop.com)) for as low as \$20.00, and they are even cheaper on eBay ([www.ebay.com](http://www.ebay.com)). Both Gamestop and eBay also have a wide selection of used cartridges that can be gutted.

- 11 74HC595 serial shift register ICs (Jameco #46105EX)
- 10 Dot Matrix LEDs (Jameco #118906EX)
- 5 2N2222A NPN transistors (Jameco #38236EX)
- 12 330 ohm resistors
- 1 27C256 32KB EEPROM (Jameco #39714EX)
- 1 Nintendo Gameboy Color
- 1 Gutted Gameboy cartridge to attach EEPROM containing LED control software

### Equipment:

- 1 EEPROM/EEPROM programmer
- PC with freeware GBDK (Gameboy Development Kit) compiler installed

### Files (See [www.nutsvolts.com/ftpindex.htm](http://www.nutsvolts.com/ftpindex.htm)):

commc.c  
data50x7.h  
sidescroll.gb  
make it.bat

transfer clock has to be set at its maximum operating frequency of 512 KHz. Anything slower would cause a flickering display. This is the reason why the Gameboy Color is necessary for this project, as the internal serial transfer clock of the original Gameboy and Gameboy Pocket are limited to only eight KHz. Hence, they can only send data at a rate of one KB per second.

## C Code for the Gameboy

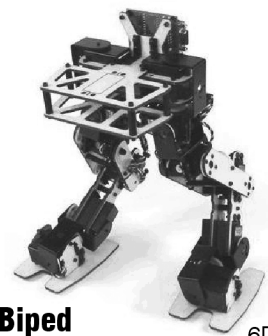
The software that runs on the Gameboy to dynamically drive the LEDs is pretty simple. The main loop of the code sends just 11 bytes out through the serial I/O port. This is done repeatedly at approximately 150 times a second to produce a bitmap pattern on the dot matrix LED. Each of the bytes sent is used to determine the output state of a shift register in the hardware. The last byte sent corresponds to the column-select shift register. This byte is used

for selecting the active column in the dot matrix LED. Listing 1 shows the main loop of the program. This section of code is continuously executed to produce a message on the dot matrix LED.

Additional effects like message side-scrolling and flashing of the display are quite simple and are written in another section of the software. We are not going to discuss them here because the focus of this article is the hardware part of the project. The point is that once the key routine needed to display a bitmap pattern on the screen is done, the rest of the extra work is all software. You can download the source code and Gameboy binaries for this project on [www.nutsvolts.com/ftpindex.htm](http://www.nutsvolts.com/ftpindex.htm) **NV**

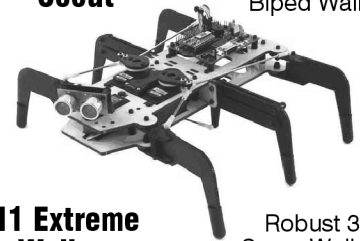
## About the Author

*Chamberlain Fong is a video game engineer in San Francisco and is currently working on a game for the Playstation Portable™. You can reach him at [spectrafft@yahoo.com](mailto:spectrafft@yahoo.com)*



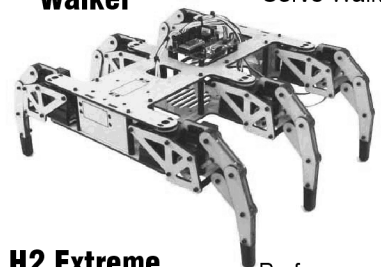
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# HDTV

## Past, Present, and Future

by Robert Diaz

**A**nalog TV's days are numbered. In a few years, we will likely see an end of analog broadcasts in the major cities. Yet, the average consumer knows very little about HDTV and even HDTV salespeople don't fully understand the history and technology behind the system. Here, I will provide a brief summery of the history, the basic technology, and potential future for HDTV.

### History

In the 1980s, the Japanese unveiled the Hi-Vision HDTV system. This sparked US interest in developing an

HDTV system. Near the end of the 1980s to the early 1990s, the FCC (Federal Communications Commission) received many proposals for HDTV systems, but the one proposal that caught the most interest was from General Instrument Corporation. Their proposal was for an all digital system. Other companies quickly followed with their digital proposals. The problem was that all the different proposals were very good, but no one system out-shined all the others.

By 1993, the FCC realized that the best solution would be to take the top contenders and form a "grand alliance" of different companies. The idea was to take the best from each proposal and incorporate that into one unified proposal. Today, the ATSC (Advanced Television Systems Committee) oversees this process.

The original timetable (established 1996 to 1997) listed the year 2006 as the last year for analog TV. Back then, January 1, 2007, must have seemed like more than enough time to make the transition, but things don't always work as planned.

In 1999, HDTV stations started to come online in 30 major cities and, by 2002, HDTV transmissions were generally available in all the other major areas. The theory was if you build it, they will come. Well, the system was built, but buyers weren't coming and investing in HDTV in large numbers.

This put the FCC into a major bind. Demand for open frequencies was huge and — as long as there is

**Table 1**

Product	50% Of Products	100% Of Products
36" TVs and larger	July 1, 2004	July 1, 2005
25" to 35" TVs	July 1, 2005	July 1, 2006
13" to 24" TVs		July 1, 2007
VCRs & Other Recorders		July 1, 2007

**Table 2**

Aspect	Ratio	Decimal	Usage / Name
4:3		1.33	Analog TV and Pre-1950 Movies
16:9		1.78	HDTV Wide Screen
37:20 (9:5)		1.85	Academy Flat (About 16.65:9)
47:20 (12:5)		2.35	Anamorphic Scope or Cinema Scope

The numbers in parenthesis are approximations of the aspect ratio.

a dual digital and analog TV system in operation — a vast amount of the radio spectrum is being tied up. A single 6 MHz TV channel can be broken into 400 narrow band FM 15 kHz voice/data channels. Bringing an end to analog TV will free up a massive amount of bandwidth, but if most of the country's TVs go blank, the fallout will be enormous.

In 2002, the FCC issued the Digital Tuner Mandate Timetable for TV Manufacturers. Manufacturers must include a digital tuner with their product (See Table 1). The TV manufacturers fought this in the courts. In the end, the FCC won and the manufacturers must now comply. Today, the FCC appears to be pushing for January 1, 2009, as the shut-off date for analog TVs. Yet it's still possible that the FCC may still pick the original shut-off date of January 1, 2007.

Even if the later date is selected, the potential outcry from consumers could be immense. Today, about 85 percent of the American public receives their TV signal via either satellite or cable. Only 15 percent of the public receives their TV signal via the broadcast system. This means that, when all analog broadcasting comes to an end January 1, 2007 or 2009, around 85 percent of the public will continue to receive TV via cable or atellite. However, the remaining 15 percent without DTV (Digital TV) reception will become a very unhappy and vocal group.

Currently, an HDTV Tuner with HDTV and standard TV outputs sells for around \$300.00. The industry expects that these tuners will sell for about \$200.00 in 2007 and around \$100.00 in 2009. A standard definition TV will work with an HDTV tuner, but the resolution must be scaled to the resolution limit of the TV.

## HDTV Standards

One of the early critical questions to be settled was the aspect ratio. Aspect ratio is the ratio of the horizontal size of the image compared to the vertical size of the image. This can be expressed as H:V or as a decimal number, where the number equals H/V. The most common aspect ratios are listed in Table 2.

The movie industry has used many aspect ratios over the years. Some of the ratios not listed above are: 1.66, 1.96, 2.20, 2.55, 2.59, 2.66, 2.75, 2.76, 2.77, and 3.00. With so many different ratios to chose from, you might assume that the task of selecting the ideal aspect ratio is impossible. However, the 16:9 ratio seemed to be the most reasonable balance between 1.33 material and 2.35 material. A full screen Academy Flat loses only four percent of the image at the edges on a 16:9 screen.

After choosing the aspect ratio, the next step was to select the resolution for HDTV. This is a good example of why decisions by committee aren't always the best. With so many people from so many different companies, everyone had their own ideas as to what should be included in the standard. The end result was not one or two, but

**Table 3**

Resolution (H x V)	Ratio	Scan Rates
1920 x 1080	16:9	60i, 30p, 24p
1280 x 720	16:9	60p, 30p, 24p
720 x 480*	16:9	60p, 60p, 30p, 24p
720 x 480*	4:3	60p, 60p, 30p, 24p
640 x 480	4:3	60p, 60p, 30p, 24p

If this wasn't messy enough, the scan rate can also be 1000/1001 or 60 --> 59.94, 30 ---> 29.97, 24 ---> 23.98 The 59.94 rate matches the current scan rate of color analog TV.

\* The 720 x 480 resolution is also written as 704 x 480, which represents the active pixels.

**In 60p** Progressive, all the lines in the image are scanned 60 times per second.

**In 60i** Interlaced, the image is scanned 60 times per second, but all of the odd lines are scanned in the first pass and then all the even lines are scanned in the second pass. It takes two passes to fully scan the image.

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## For Additional Information

A wealth of information, links, and resources about DTV — [www.dtv.gov](http://www.dtv.gov)

Online version of TV Technology Magazine — [www.tvtechnology.com](http://www.tvtechnology.com)

DTV Resources — [www.checkhd.com](http://www.checkhd.com)

National Association of Broadcasters — [www.nab.org](http://www.nab.org)

HDTV Public Notice — [www.myfreehdtv.org](http://www.myfreehdtv.org)

Digital TV Information — [www.digitaltvzone.com](http://www.digitaltvzone.com)

Determine what antenna to use — [www.antennaweb.org](http://www.antennaweb.org)

18 different standards. The standards fall into five different resolution/ratio groups (Table 3).

Broadcasters are not required to transmit in every possible resolution and frame rate, but a TV receiver must be able to display all 18 of these possible resolutions and frame rates. Many HDTV sets have a fixed native resolution and convert the incoming signal to its native resolution and frame rate.

As a very general rule of thumb, for normal viewing distances of 10 to 12 feet, 1,280 x 720 is good enough for a 60-inch screen or smaller and 720 x 480 or 640 x 480 is good enough for a 34-inch or 32-inch screen. Keep in mind that this is only a general rule and what's good enough for one person may not be good enough for another.

A 1,920 x 1,080 pixel image at 30p or 60i generates about 995 Mb/second of uncompressed video data. Even the lowest resolution — 640 x 480 — and the lowest frame rate — 24p — generates about 118 Mb/second. This is more data than our 19.39 Mb/second DTV transmitters can handle.

The solution is to use data compression to reduce the amount of information. Try to imagine a single frame of video placed onto a giant Excel spreadsheet where each cell represents a single pixel. As we look over the numbers, certain patterns will appear. By using a shorthand notation to describe these patterns, we would come up with a reasonable summary of what all the cells should contain. The shorthand notation won't produce an exact reproduction of all the data in all the cells, but should be a reasonably close approximation to the original data.

Video is more than a single frame; the other video frames that follow should be close to the data in our key frame. If we record only a summary of the differences between frames, the amount of data recorded is reduced. This is a simplified explanation to how MPEG-II works, but the main thing to remember is that the final image is close enough to the original that few notice the minor differences.

## Transmission Standard

The FCC chose 8-VSB — Eight Level Vestigial Sideband — as the system to transmit the digital data. In Europe, they use COFDM — Coded Orthogonal Frequency Division Multiplexing. The 8-VSB uses a

single carrier frequency with all the data sent in a high speed serial stream on that carrier. COFDM uses hundreds of carrier frequencies to transmit the data in a parallel fashion. With COFDM, each carrier transmits the data slower; since there are so many in parallel, the data rate would be about 18.7 Mb/second; which is close to the 8-VSB's rate.

In the late 1990s, Sinclair Broadcast Group began a major push to promote COFDM as the standard for broadcast rather than 8-VSB. COFDM is less sensitive to multi-path or ghosting and has an optional mode that is slower, but more robust and could be received indoors; 8-VSB lacked a robust mode and could not be received indoors. Like many things in the engineering world, it turned out to be a trade-off. COFDM is more sensitive to impulse noise from motors and electrical arcing and — in terms of transmitter power — does not do as well as 8-VSB. In the end, the FCC rejected Sinclair's request to use COFDM.

Since that time, major improvements occurred in each generation of 8-VSB receivers. The fifth and latest generation 8-VSB receivers incorporate powerful digital signal processing that can handle a multi-path signal as strong as the direct signal. In April 2004, the ATSC group approved E-VSB (Enhanced VSB) as an optional mode of transmission. In the future, broadcasters will incorporate a low resolution — but highly robust — signal for weak signal conditions along with the standard high definition signal. The beauty of E-VSB is that the additional mode does not render all the older 8-VSB receivers obsolete. The older receivers just ignore the robust signal and receive the standard signal.

## The Future

HDTV prices continue to fall and are expected to drop even more in coming years. Still, the future isn't perfect for everyone. The broadcast flag raises all sorts of issues with the consumers' future abilities to record programs for later viewing or keep a personal library of their favorite shows.

Despite the dark clouds that some would like to focus on, HDTV opens the door to new and exciting possibilities for the future. For those who missed the 5 or 6 P.M. news, ABC is now broadcasting a news show on the second channel in their HDTV data stream. Likewise, if your favorite program is interrupted by something, you may be able to see it on one of the alternate channels. Some stations — like PBS — broadcast four different programs at once. Who knows what other ideas will be possible in the future? The future of TV is coming, stay tuned ... **NV**

## About the Author

Bob Diaz teaches electronics and computer technology at El Camino College in Torrance, CA. He has always been interested in video and has followed the HDTV development closely for the past two decades.

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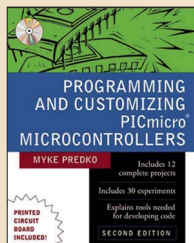
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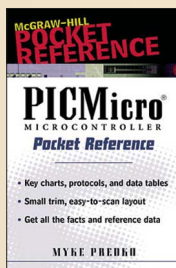
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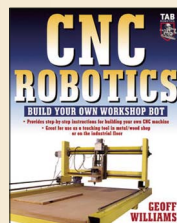


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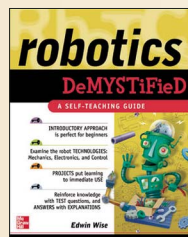
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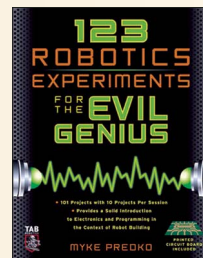
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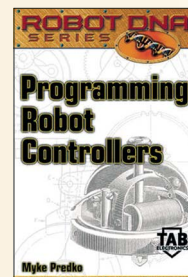
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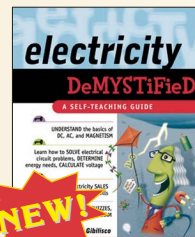


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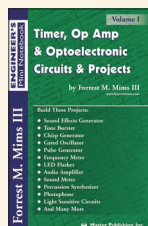


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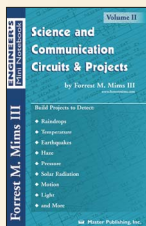
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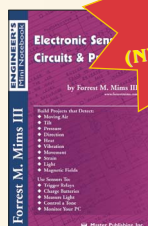
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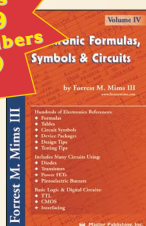
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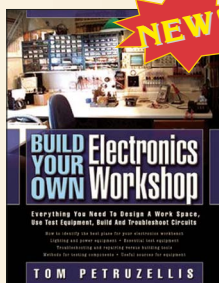
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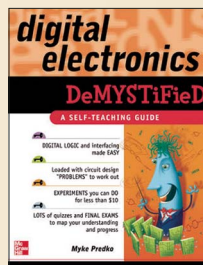
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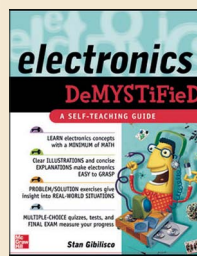
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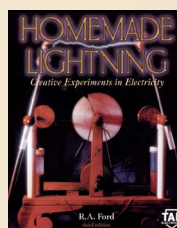


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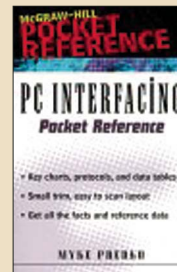
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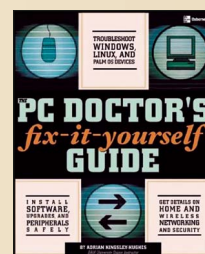
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# THE PID CONTROLLER

## Part 3

by Aaron Dahlen

*Welcome to the world of control systems. This is truly one of the most exciting and fascinating aspects of electronics.*

Let's review where we have been. In Part 1, we learned what the terms P, I, and D represent. Our discussion was based on analog models, where each component of the PID controller was comprised of a simple op-amp circuit. In Part 2, we learned how the various terms interacted with a mechanical system and we learned how to tune the PID controller for optimal system response.

This month, we are going to take the training wheels off and construct a fully functional digital PID controller. We will be using a ZILOG microcontroller as the brain of our control system, and the same servo motor that was presented in the previous installments will be used. In conclusion, we will compare analog and digital PID controllers.

### Microcontrollers

In many ways, this was the hardest section to write. I had to make a difficult decision: What microcontroller platform do I use? My first preference was to use the BASIC Stamp. After all, most of us *Nuts & Volts* readers are familiar with this processor and it is quite capable. Unfortunately, we need more horsepower to perform the PID algorithm. We also need the performance that can be achieved using a true interrupt service routine.

Obviously, the Stamp isn't the only microprocessor. There are dozens of manufacturers, so you can take your pick from A to Z: Analog Devices, Atmel, Cygnal, Microchip, Motorola, Rabbit, Renesas, ZILOG .... We could use any of these micros, but luckily for us, one product stands out among the rest. At the very end of the list, we come to ZILOG.

ZILOG is the grandfather of the microprocessor world. They have been around since 1974 (back in the Nixon presidency), and in that time, they have manufactured billions of micros. Their newest Encore! series has just what we are looking for. I rushed out and purchased a Z8642 development kit, and included in this kit is a development circuit board and an in-circuit debugger (shown in Photo 1). The Z86423 processor mounted on the board has gobs of speed, 64K of Flash memory, 2K of RAM, and powerful built-in peripherals. The kit also includes a full-featured C compiler, all for the price of \$39.95! This price is a dream; the last kit I purchased with this many features put me back over \$600.00 and frankly, it doesn't work nearly as well as the ZILOG system.

### Why Learn C?

If I had to choose a single reason to learn C, it would be that the language is not processor-specific. All of the micros listed in the previous section may be coded in C, as it appears that C is the standard programming language for the micro. With C, you can easily switch to a new micro; you will already know the language. You only need to focus on the hardware differences. With C, you will be able to use code written for one processor on another one. Finally, C is a very powerful language, as it provides high level functions such as floating point math routines and string manipulation. It also allows you to access all of the micro's hardware registers. If it can be done, C can do it.

We don't see many articles using C in the pages of *Nuts & Volts*. Cost is certainly an issue. Up till now, a C compiler for a micro would cost upwards of \$400.00. Complexity is another problem, as it exists on two levels. First, the C language itself can be overwhelming and the operations of basic elements are not obvious at first. The language syntax has caused more than one newbie to pull out their hair — all those braces must be in the right places. Second, the micro-processor itself is complex. There are many registers that must be configured before the micro will function.

If you are new to microprocessors and would like to learn how to use C, I have this advice: Don't try to learn C on a micro! Use your PC. There are hundreds of books available to assist you, and if you are new to programming, you may want to cut your teeth on the Python programming language. Python performs many of its functions in the same way as C does, but it will also force you to use structured programming. Python is available free of charge at [www.python.org](http://www.python.org). You may also wish to download the book *How to Think Like a Computer Scientist* by Allen B. Downey, Jeffrey Elkner and Chris Meyers, from Green Tea Press. Another alternative is to learn using C++. A free compiler is available at [www.bloodshed.net](http://www.bloodshed.net). The C++ language is similar to C, but skips the stuff on classes and objects.

Once you have learned how to code C on a PC, you can switch back to the micro. The process of learning the micro's hardware will be much easier if you know how to manipulate the C language. Okay, enough about C. Let's get back to our main topic and learn how to implement a digital PID using C, naturally.

## PID Routine

The PID routine in C has the following form:

```
void PID_ () {
    measure_plant();
    calc_error();
    calc_proportional();
    calc_integral();
    calc_derivative();
    calc_PID_sum();
    drive_plant();
}
```

MARCH 2005

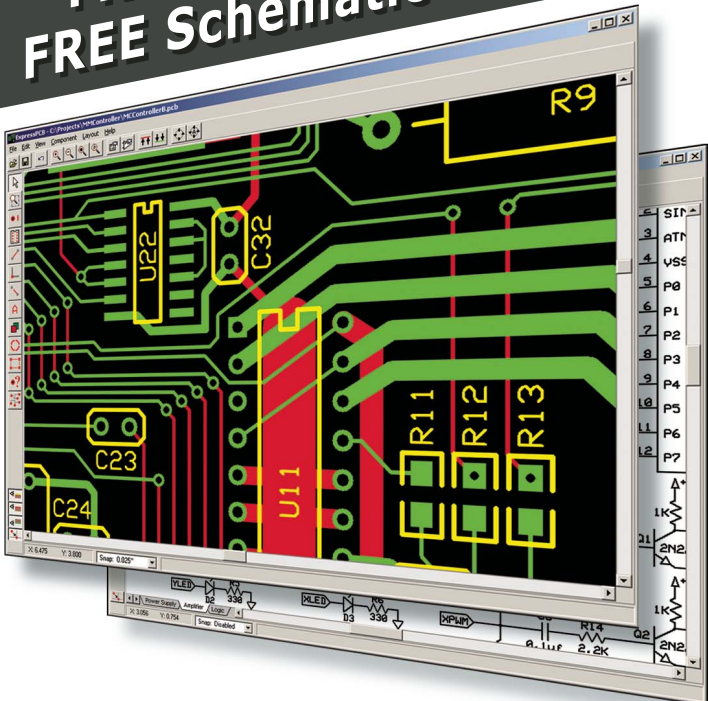
In many respects, this is the same process that was being performed by the analog circuitry. This is a parallel process. The sums of the P, I, and D terms are added together to determine the drive for the servo motor. This month, we will use the more generic term "plant" to refer to the process we are controlling instead of servo motor.

The majority of the variables used in this program are external, and by making the variables external (global), they are available across functions. For example, the variable error is first calculated by the function calc\_error.

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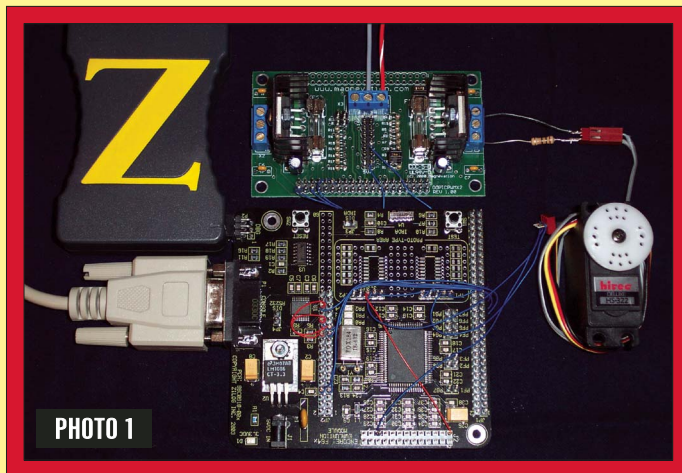
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It is then used by `calc_proportional`, `calc_integral`, and by `main`.

A base requirement for the PID routine is that the time between iterations must be consistent. If this is not the case, the integral and differential components will appear to have noise and will cause less than ideal operation. This timing requirement is met with an interrupt service routine; we will resume this discussion later in this article.

As written, this PID routine executes in approximately 700  $\mu\text{s}$  (18.432 MHz XTAL). This allows the routine to be executed over 1,500 times a second.

## Measure Plant

The first step to implementing a PID controller is to measure the process. We will be controlling the same servo motor as we did in the previous installments. This servo consists of a DC motor with a variable resistor as a feedback element. It is this feedback resistor that must be measured. The ZILOG processor has a built-in AD converter to perform this function for us. This ZILOG converter will convert an analog signal into a 10-bit number. The input voltage to the converter must be between zero and 3.3 VDC, and if these voltages are exceeded, the micro will be damaged.

The function to measure the plant is shown here. The function `get_AD` was written to return the 10-bit value of the selected AD channel.

```
void measure_plant(){
    plant = get_AD (ch0);
}
```

## Calculate Error

The second step is to calculate the error. Recall that error is the difference between the desired set point and actual position of the plant measured by the AD converter.

```
void calc_error(){
    error = setpoint - plant;
}
```

## Calculate Proportional

We calculate the proportional component by multiplying the error by a proportional gain term. I have chosen to represent the proportional gain term as integers. If your application requires more adjustment, a float may be used.

Recall that the outputs of the op-amp circuits were limited by the positive and negative voltage supplied to the op-amps. We will perform a similar operation in the micro. The proportional term is limited to an absolute value that is less than or equal to the saturation term.

```
void calc_proportional(){
    proportional = error * proportional_gain;
    if (abs(proportional) >= saturation){
        if (proportional > 0)
            proportional = saturation;
        else
            proportional = -saturation;
    }
}
```

## Integral

Previously, we defined integral as the accumulation of error over time. In the op-amp circuit, we charged/discharged a capacitor. Over time, the capacitor “accumulated” the error. In the digital PID, we will not use a capacitor, but instead, we will use a floating-point register as the accumulator. We will add/subtract the error from this accumulating register every time the PID routine is implemented.

Recall that the op-amp integrator had a resistor that was adjusted to change the speed at which the capacitor was charged/discharged. The charge/discharge speed of the digital accumulator is changed by first multiplying the error by a floating point number. Using this type of operation, we can change the speed of the integrator over a wide range. Also, the speed is dependent on how often the PID routine is executed. Obviously, if the time between iterations is small, the integral term will grow faster.

The integral is limited to an absolute maximum value by comparing it to the saturation term. Also, note that the accumulator is implemented as a static variable. That is, the value stored in the accumulator does not vanish when the function exits.

Finally, a lock-out function is implemented to prevent integral wind-up. This lock-out function is based on the error term. This implementation is different than the op-amp iteration. In the op-amp circuit, we monitored the output of the PID loop. This was possible, since the analog circuit responds more or less instantaneously. This is not the case in the digital implementation. The PID rou-

tine is active during a finite amount of time. We could have used the last iteration's PID output, but this is not ideal, since a large change in the set point would not be seen. This would cause a large error to be integrated, causing integral overshoot: the very effect we are trying to prevent.

Monitoring the error term is a good compromise. For the majority of situations, if the error is large, the PID output will be large. The only problem is that it does not account for the differentiator term. However, if the plant is moving fast, then presumably there is a large error.

```
void calc_integral(){
    static int accumulator;
    if (abs(error) <= int_lockout){
        accumulator += error * integral_gain;
        integral = accumulator;
        if (abs(integral) >= saturation){
            if (integral > 0){
                integral = saturation;
                accumulator = saturation;
            }
            else{
                integral = -saturation;
                accumulator = -saturation;
            }
        }
    }
}
```

## Derivative

The derivative term is a measure of how fast the plant is moving. If the plant is moving, then the voltage will be different between PID iterations. The faster the plant is moving, the greater the difference between iterations will be.

The derivative term is highly dependent upon the time between iterations of the PID routine. If the time is short, the difference between any two voltage measurements will be small. Likewise, if the time is long, the derivative term will be large. This time between iterations must be constant. If the time changes, the differential term will not be a true measure of the plant speed. Time variation can result in differentiator "noise."

The actual derivative term is calculated by first finding the difference between the present plant location and the last location. This number is then multiplied by the derivative gain term. Finally, the function verifies that the term is less than the saturation limit.

```
void calc_derivative(){
    derivative = plant - last_plant;
    derivative = derivative * derivative_gain;
    if (derivative > 0)
        derivative = saturation;
    else
        derivative = -saturation;
    last_plant = plant;
}
```

MARCH 2005

## PIC Programming Made Easy! Proton+ PICBASIC Development Suite





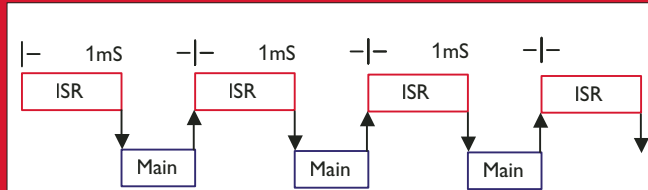


FIGURE 1

## Calculate PID Sum

After the individual P, I, and D terms have been calculated, they are added together to form the PID\_sum term. Actually, the D term is subtracted from the sum of the P and I terms. This is done because the D term is derived from the plant drive. A final comparison is made with the saturation term to ensure that the PID sum term is within the proper limits.

```
void calc_PID_sum(){
    PID_sum = proportional + integral - derivative;
    if (abs(PID_sum) >= saturation){
        if (PID_sum > 0)
            PID_sum = saturation;
        else
            PID_sum = -saturation;
    }
}
```

## Drive Plant

At this point, the PID calculation is complete, and we are left with a value in PID\_sum that we will now use to drive the servo motor. This value may be either positive or negative, depending on the required correction. The motor will be driven using one of the ZILOG's PWMs (Pulse Width Modulators) and an external H-bridge.

The ZILOG micro has several built-in hardware PWMs, which are joys to work with. Since the PWM is implemented in hardware, it is a set-it-and-forget-it device. It operates at relatively high speeds — approximately 18 KHz in this application with 10-bits of resolution. To use the PWM, we configure the appropriate timer, set the period, and set the duty cycle. The hardware takes care of the rest. The PWM will continue to operate automatically in the background until we tell it to stop or change a parameter, which is ideal for our PID routine. We only need to update the PWM once per iteration.

A Magnation H-bridge is used to drive the motor. This circuit board contains two National Semiconductor LMD18200 power H-bridges, only one of which is used. It is capable of supplying three amps at up to 55 volts. The chip contains current limiting and thermal detection circuitry. Also, the chip is compatible with the 3.3 VDC logic level of the ZILOG processor.

The LMD18200 requires three control signals: brake, direction, and a PWM. The brake line will stop the motor (active high). The direction line will change the rotational direction of the motor, effectively changing the output polarity (sign) of the H-bridge. The PWM line determines the average voltage (magnitude) of the drive signal sent to the motor.

The function drive\_plant is responsible for controlling the drive signals to the LMD18200 H-bridge. The basic routine is shown here. The first line of the code disables the motor brake. The if/else pair sets the motor direction (polarity) based on the sign of the PID\_sum variable. The final line sets the duty cycle of the PWM to the absolute value of the PID\_sum drive variable.

```
void drive_plant(){
    off_PWM3_brake( );
    if (PID_sum < 0)
        cw_PWM3( );
    else
        ccw_PWM3( );
    set_PWM3 (abs(PID_sum));
}
```

## Interrupt Service Routine

The timing of the PID routine is important, as the Integral and Derivative functions must occur at precisely timed intervals. Time variations between intervals will show up as noise on the derivative terms and will degrade performance. The actual time between iterations is adjustable (i.e., the Interrupt Service Routine can occur every microsecond or every minute). However, the time interval chosen must be consistent; if you selected a microsecond, then there must be exactly one microsecond between PID iterations.

The best method of implementing these time delays is to use an Interrupt Service Routine. An ISR is like the ringing of a telephone. Normally, we just go about day-to-day activities, but — when that phone rings — it gets our immediate atten-

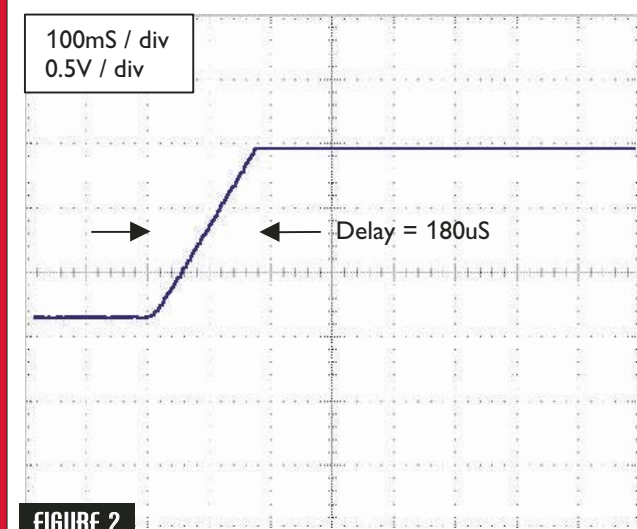


FIGURE 2

tion. We stop what we are doing and answer it, and the micro does the same thing. Normally, it performs the main line code, but when an interrupt occurs, the micro immediately stops executing the main line code and “vectors” (goes to) the ISR.

The ZILOG micro has multiple sources of interrupts. For this application, we are only concerned with timer 0. This timer is set to interrupt the micro every one mS. This results in the code execution shown in Figure 1. Just like clockwork, timer 0 interrupts the micro. The CPU vectors to the ISR, and the ISR executes the PID routine. When the PID routine is complete, the program returns to the previous tasks.

Setting up an ISR in the ZILOG micro involves setting up the timer to overflow every microsecond, enabling the timer interrupt function. Finally, we must tell the micro what code to execute during the ISR. This information is found in the timer.c file, and the demo program included with the ZILOG development kit also contains an ISR that you can view. Dissecting this simple demo program is a good way to learn how to operate the micro.

## How Do I Tune a Digital PID?

Generally, you can tune the digital PID the same way you tuned the analog PID. The Proportional, Integral, and Derivative gains are present and perform the same functions as they did in the analog implementation. I have added a simple user interface that allows you to adjust the individual parameters via a terminal program. The settings are ANSI, 57600, and 8N1. You will see the following screen:

```
Welcome to digital PID control with the ZILOG Processor.
Select the corresponding number to update a parameter.
```

- 1) Proportional gain = 10
- 2) Integral gain = 0.010000
- 3) Derivative gain = 50
- 4) Integral lockout = 700
- 5) PID Loop time = 1 mS
- 6) Desired Setpoint = 480
  
- 7) For continuous display of the PID terms
- 8) To toggle the step function
- 9) To set the step function parameters
  - time between steps = 5000 mS
  - high step = 400
  - low step = 450

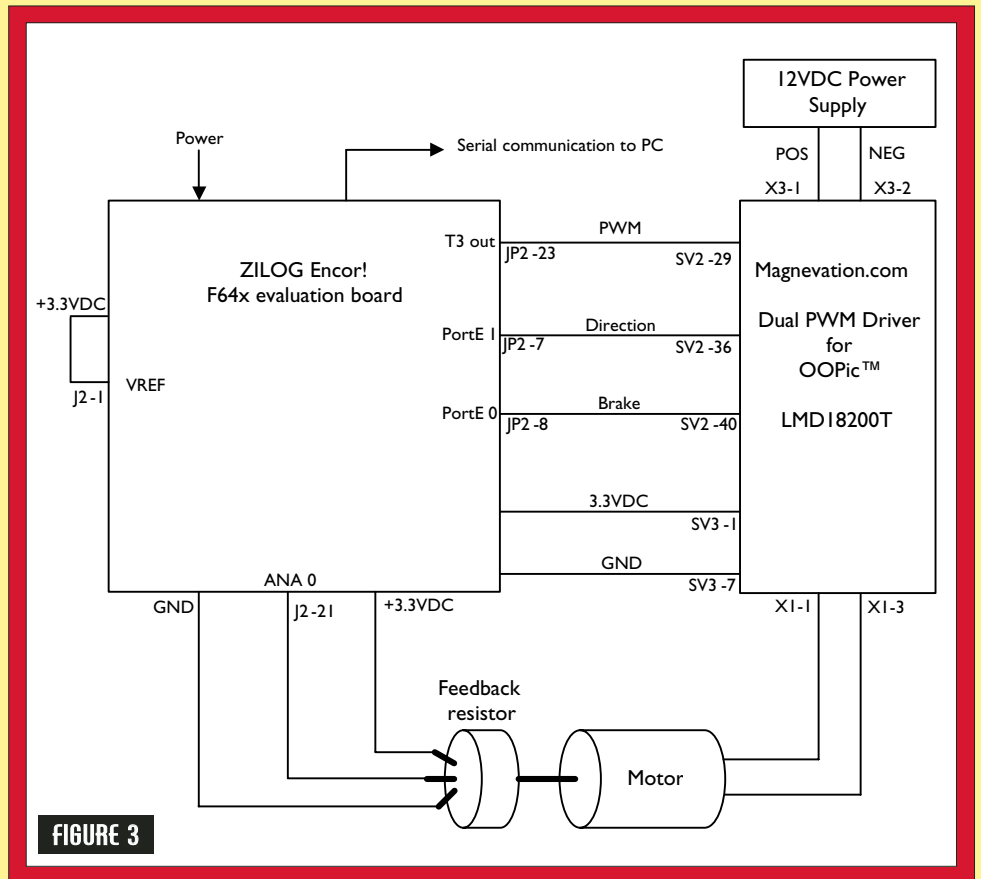


FIGURE 3

To adjust a parameter, type the number you wish to change. Option 7 is particularly useful during the tuning, and if you select this option, you will be presented with the following text:

```
plant = 500, error = 0, P = 0, I = -46, D = 0, PID_sum
= -46
```

New lines are sent as fast as the micro can process them, and this allows you to see — at a glance — what the PID algorithm is doing. Each of the individual PID components are displayed along with the sum of the PID terms. The plant position and the error are also displayed. This data may be plotted by importing it into your favorite spreadsheet program.

An additional feature that is very useful is the ability to adjust the time between PID loop iterations. I have set the software up so that the loop time may be adjusted between one mS and one minute. This makes the PID adaptable to many different types of systems. For the servo motor, the one mS setting works very well. For slower systems — such as thermal or chemical systems — a longer loop time is desirable.

Be very careful when you adjust the loop time, as small changes can have a profound effect on the integral and derivative gains of the system. I lost most of the servo motor gears by making this mistake! Remember



those limit switches?

## Analog Versus Digital

The digital PID controller produces results that are on par with the analog system, as seen in Figure 2. I have observed that the derivative component of the digital controller is more responsive. The derivative gain may be set higher, thereby minimizing overshoot. The rise time is also improved, which may be attributed to the higher voltage applied to the motor.

It is tempting to state that the digital PID is superior to the analog system. After all, isn't digital the wave of the future? It turns out that determining which is the best PID controller depends on the application in question.

- If you have a fast system, then use the analog PID. An example of a fast system is a power supply or a high-speed motor.

- Conversely, if you have a slow system, then use the digital controller. Thermostatic control is an example of a slow system. It is difficult to make an analog integrator or differentiator that will function at these long

time constants.

- For general-purpose control in a variety of situations, digital control is preferable. The ability to make adjustments in software is much easier than having to change hardware.

- The digital system is preferred for high power systems. The PWM output scheme is more efficient and scalable.

## Next Step

In this series of articles, you have used a simple servo motor and the "plant." The servo motor provided a good starting point for the PID, since it is a relatively slow system that is easy to see in operation. The next step is to adapt the lessons learned on the servo motor to new applications. A few examples come to mind:

- *Improve the servo motor.* At best, a resistor is a poor device to use to measure position in a mechanical system. It has poor resolution, is susceptible to noise, and has limited life. A better solution is to use a non-contact measurement system. A quadrature encoder mounted on the motor would have more resolution, less noise susceptibility, and longer life.

- *Change the measured parameter.* In this article, we have focused on controlling the angular position of a servo motor, and the methods and ideas may be applied to measure distance traveled. A PID controller is a natural addition to a robot.

With the PID, you could measure the distance the robot has traveled, and you could control acceleration. Your robot would have the ability to operate on an incline, since the integral control would keep your bot at the desired position.

- *Digital control of a PWM power supply:* This application was mentioned in Part 1. A PID controller would allow you to control the voltage and current of a power supply. If you really want a challenge, try to construct a maximum power point tracker.

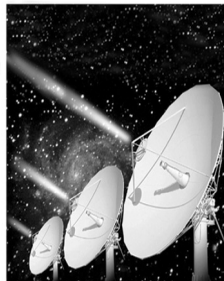
- *Thermal control:* The digital PID is capable of controlling a system with long time constants. This makes it an ideal platform for controlling thermal systems. A digital thermometer — such as the Dallas DS1624 — could be used as the sensing element. This combination would produce an accurate thermostat.

With this new information, you are well on your way to producing high-performance control systems, and I hope you find control systems engineering as exciting as I do. The training wheels are off. Go find out where the PID can take you! **NV**

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# GETTING STARTED WITH PLCs

## .. PART 2 ..

BY DAVID WARD

Last month, Part 1 provided a basic introduction to PLC programming, and this month, additional information and PLC programming features will be discussed, including a more complicated circuit — the roll-up door opener controller. The first article also left us with a start/stop circuit that did not have a hold-in feature; you had to hold the start button in to keep the motor running, which is inconvenient.

To add a hold-in feature to the original start/stop circuit from Part 1, you must first go offline if you are currently online with the PLC. To do this, change to offline in the remote-run pull-down box and then modify the ladder diagram by adding a branch parallel to the start button with an XIC contact with the address O:0/0 (Figure 1). You may notice a series of the letter “e” appearing to the left side of the rung after you make modifications to it. This indicates that the rung has been changed or “edited” and has not been verified again after the changes were made. Be aware that you cannot make changes when in the REMOTE RUN mode with the PLC. You must go offline and then download the changes back into the PLC before you can test them.

Verify the edited rung and go through the download process as you did before. Try out the new hold-in feature that the auxiliary contacts parallel to the start switch provide. These auxiliary contacts — CR1 parallel to the start XIC — are really a logical bit in the software and don’t physically exist outside of the PLC’s memo-

ry. Using these internal contacts can be a great thing, but they have some drawbacks, as well. For example, if the circuit was being used to run a lubrication pump and the pump didn’t actually come on, the PLC would not know that it wasn’t actually running and could enable other items that might be damaged by the lack of lubrication. To overcome this, auxiliary contacts on the motor contactor could be wired back into another input screw terminal. Therefore, if the motor didn’t actually start running, the rung would be false as soon as the start button was released. To change the internal hold-in contacts to external contacts, you simply need to change the address from an output address (O:0/0) to an input address like I:0/2.

Last month, I mentioned that many features could be added to a basic start/stop motor control circuit con-

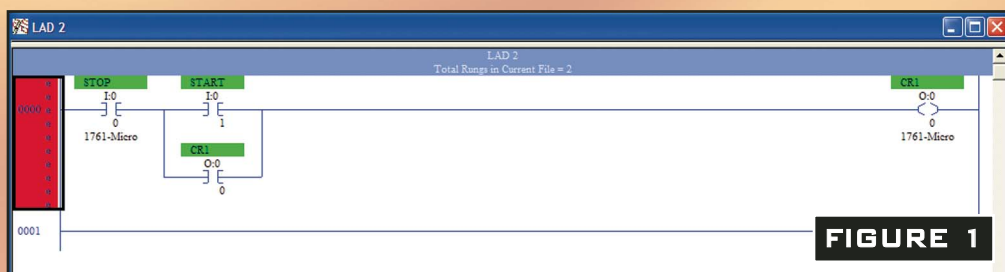


FIGURE 1

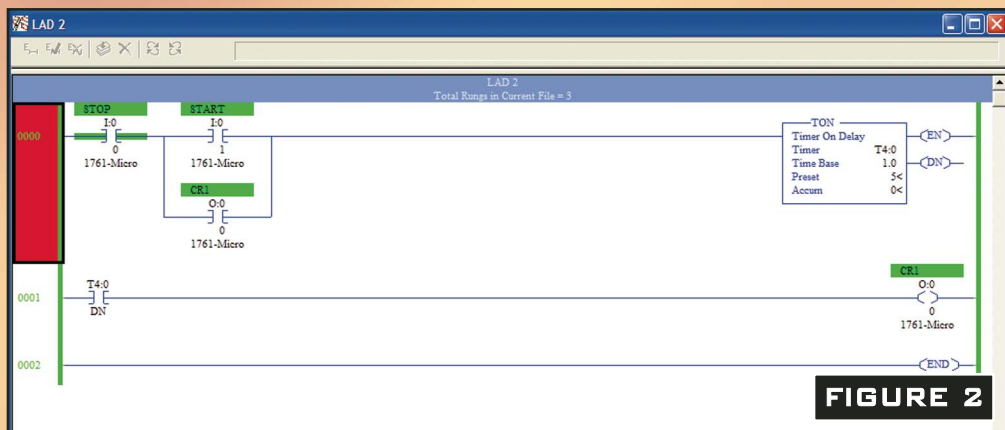
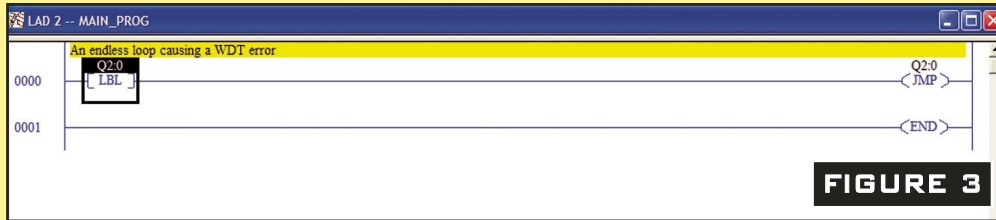


FIGURE 2



# GETTING STARTED WITH PLCs



**FIGURE 3**

trolled by a PLC via software rather than by adding or changing hardware (as would be needed in a hard-wired circuit). This makes the PLC circuit much more flexible. Let's add a delay-on timer, as was mentioned last month, to delay the starting of the motor until after the operator has pressed the start button for five seconds. This would prevent an unintentional pressing of the push-button from starting the motor (Figure 2).

Notice that a new rung was inserted and that the OTE for CR1 was moved onto the new rung with an XIC symbol labeled T4:0/DN controlling it. A delay-on timer (TON), T4:0, was put in where the original CR1 OTE was placed. The timer information that needs to be entered into it is: The Timer number is T4:0; the Time Base is 1.0 (meaning one second); the Preset is 5 (how long you want it to time); and the Accum (accumulated value) is where you can observe it incrementing once every second when you are online with the PLC.

If you entered in everything correctly after you downloaded the program, you should now have to press and hold the start button for five seconds before the output becomes enabled. The stop button will still turn the output off immediately whenever it is pressed. The CR1 OTE is now enabled by XIC T4:0/DN — the "Done" bit of

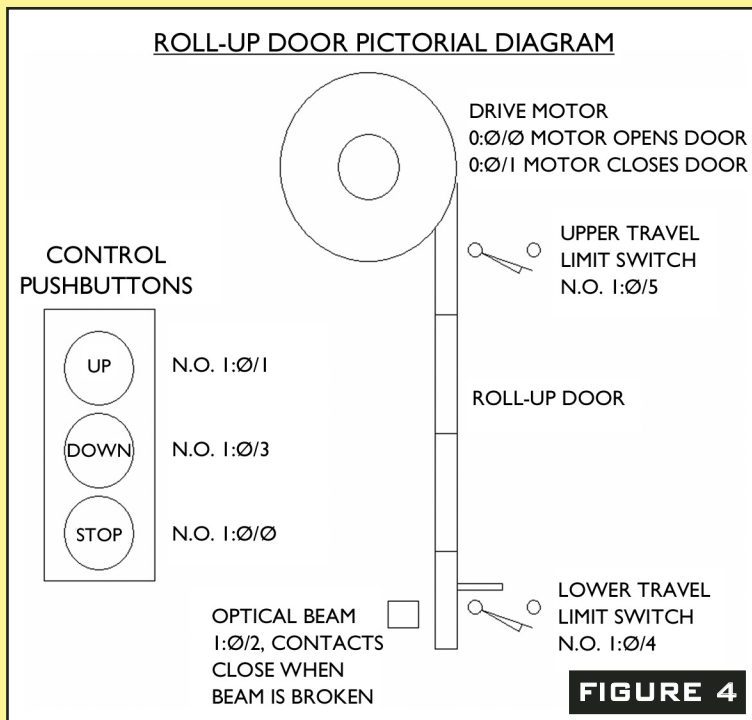
some programs and instructions work the way they do. Allen Bradley PLCs start in the upper left corner of the ladder diagram and work from the left to the right and from the top to the bottom until the entire ladder diagram has been analyzed. The PLC analyzes each rung, one by one, looking at its inputs, symbols, and instructions to determine if the rung is true or false. The PLC will then store the appropriate condition for that rung's output in a table, but it will not actually change the output at this point.

Only after analyzing all of the rungs in the ladder diagram will the PLC update the outputs from the output table. It will then take care of housekeeping chores, such as communicating with the PC, etc., then start the program scan all over again from the top-left corner of the ladder diagram. This entire scan time is monitored by a watchdog timer, and if the watchdog timer times out, the PLC will go into a "fault" condition and stop executing its program. The PLC is designed to operate this way in the event that a particular rung, for example, gets into an endless loop and the PLC cannot complete the program scan and begin over again on the next scan.

The ladder diagram in Figure 3 will cause the watchdog timer to time out and a "fault" situation to occur. You can try this out to see what happens during a PLC fault. The ladder diagram in Figure 3 causes an "endless loop" so that the PLC software does not have a chance to reset the watchdog timer after the first program scan hits the rung.

Programmers familiar with other types of software might think that the output on a particular rung would be updated before the next rung was analyzed, but this is not what occurs. Knowing how the PLC analyzes and executes a ladder diagram program can help in troubleshooting why a particular output is not coming on or going off as the programmer intended it to. You can even see where it should be "ON" or "OFF" in the ladder diagram, but you will usually find a rung further down that makes that particular output false, not allowing it to turn on or off as you thought it should.

It makes sense to analyze and execute PLC programs in this manner and would not be desirable to have outputs constantly coming on and off during a program scan as rungs were determined to be true and false while the ladder diagram was analyzed, rung by rung. You can also see that, the



**FIGURE 4**

## ■ ■ PART 2 ■ ■

longer a ladder diagram is, the longer it takes to complete a program scan. This means that the inputs would not be examined as often in a long ladder diagram as they would in a shorter one.

Well, that may seem like quite a bit of work to get your first circuits working on a PLC, but future circuits will come along much more easily. As a final example circuit and one with a little more complexity, let's design an industrial roll-up door opener similar to the one in the diagram in Figure 4.

The inputs and connections are assigned as follows: I:0/0 is connected to an NC "stop" push-button. I:0/1 is connected to a NO "up" push-button. I:0/2 is connected to an optical sensor (the input is true when the beam is broken). I:0/3 is connected to an NC "down" push-button. I:0/4 is connected to an NO lower travel limit switch. Finally, I:0/5 is connected to an NO upper travel limit switch.

The output connections are assigned as follows: O:0/0 will make the door motor bring the door up or open the door, and O:0/1 will make the door motor bring the door down or close the door. The door will open as follows: Pressing the "up" button will open the door until the upper travel limit switch is hit or the "stop" button is pressed. (The operator will not need to hold the "up" button, as it can be pressed momentarily and released.) Pressing the "stop" button will stop the upward or downward travel of the door if the operator desires to have the door stop at a partially open position.

Even if the optical sensor beam is broken during a door opening, it will not stop the action. The door will close as follows: Pressing the "down" button will close the door until the lower travel limit switch is hit, the "stop" button is pressed, or the optical sensor beam has been broken (something is in the door opening, blocking the beam). The operator will not need to hold the "down" button during a closing operation. If the optical beam is broken during a door closing, the motor will stop going down, reverse, and go back up until the upper travel limit switch is hit or the "stop" button is pressed.

There are probably many different ways to get the ladder-logic program to perform as described previously, but the printout that I used can be seen in Figure 5. This is a simple door opener system, but other options could be added. For example, a blocked optical sensor could sound an alarm; a counter could be added with an output indicator to tell the operator when the door needs servicing after so many cycles; and perhaps an input from a fire alarm system could be added to close the door in case of a fire.

You will notice a few new symbols in Figure 5 that have not been mentioned previously. The outputs are OTLs (output latches) and OTUs (output unlatches), rather than the OTEs (output enable) that were shown previously. An OTE output is only true while the rung that it is on is true.

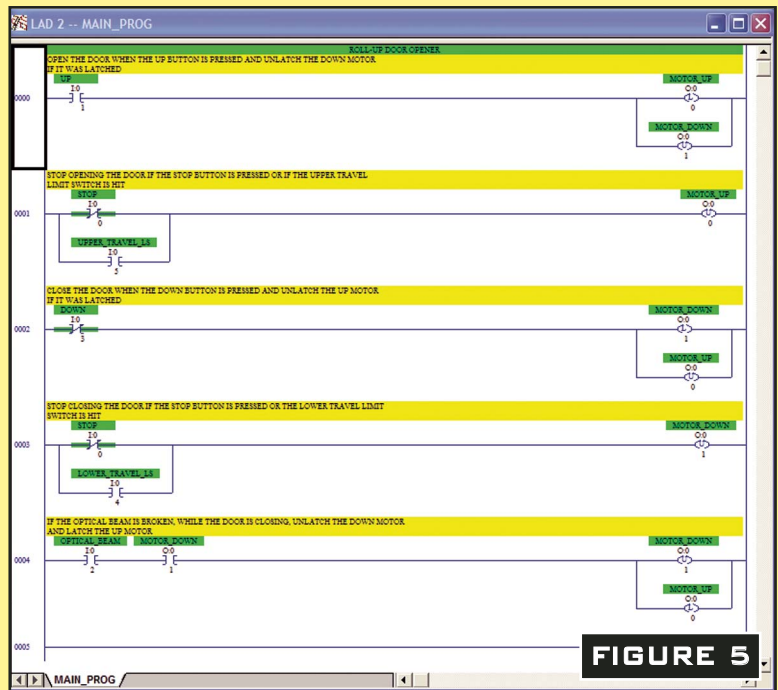


FIGURE 5

As soon as the rung is not true, the OTE output goes to an off condition. An OTL, on the other hand, can be latched

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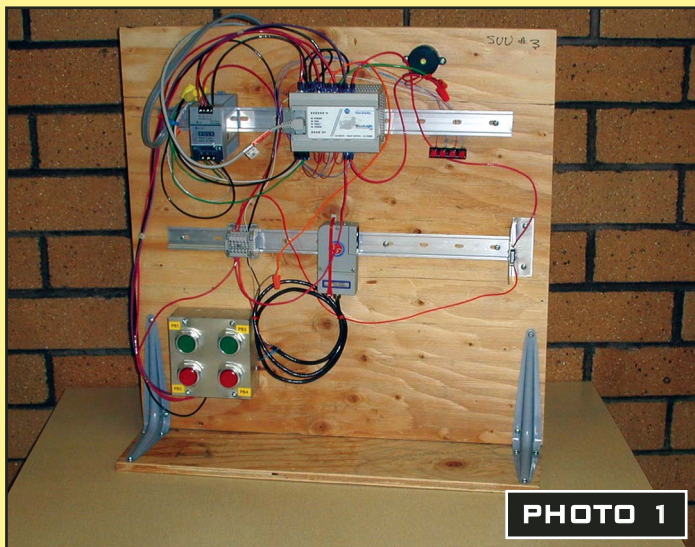
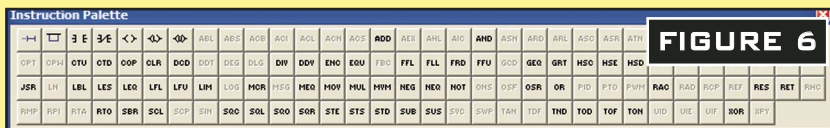
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# GETTING STARTED WITH PLCs



on as true when the rung is true for only a single program scan and will stay true or on until it is unlatched by an OTU symbol later on.

Note also that two of the inputs used on the demonstration circuit are normally closed push-buttons: the "stop" button, connected to I:0/0, and the "down" button, connected to I:0/3. If you were to use normally open switches instead, you would simply need to change their symbols from an XIC to an XIO in the ladder program to keep the program functioning in the same manner.

Hopefully, this article has given you a good start in PLC programming and understanding their operation. Once the basics of PLCs are understood, many applications should come to mind. These two articles have only introduced a few basics of PLC programming; there are many other symbols, features, and commands available to the PLC programmer, most of which are covered quite well in Richard Cox's book on programmable controllers.

You can also view all of the instructions and symbols available to you by displaying the instruction palette in RSLogix. You can display the instruction palette in two ways: Press ALT+4 or select Instruction Palette from the View pull-down menu. You may notice that some of the symbols are grayed-out and may not be available for the basic 10-point PLCs (Figure 6).

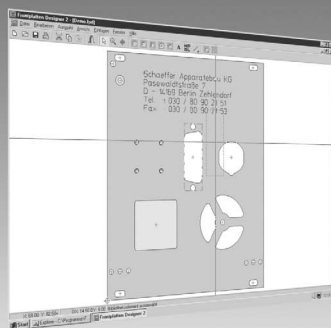
I have made my own PLC trainer (Photo 1) for testing PLC programs, such as the roll-up door opener. This trainer makes working with PLCs more convenient, as well as being portable. My PLC trainer has an NC stop push-button connected to I:0/0, a start NO push-button connected to I:0/1, a photo eye connected to I:0/2, another NC stop push-button connected to I:0/3, another NO start push-button connected to I:0/4, and an NO limit switch connected to I:0/5. On the output side, several 24 VDC lamps were added to display the output status and a piezo alarm, as well.

Although it is nice to use industrial-quality switches for the PLCs, they can be quite expensive, about \$40.00 per switch. You can use less expensive switches for program testing and learning.

Now it's time to do some brainstorming and see where you might put a PLC to work for you. The Allen Bradley website — **www.ab.com** — offers great online assistance for their PLC products: manuals, technical data, and articles featuring PLC applications. **NV**

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## AUTHOR BIO

Dave Ward has been teaching Electronics Engineering Technology courses at Southern Utah University since 1985. His hobbies include: amateur radio (N7HYA), robotics (SUU has a GM Fanuc industrial robot), radio-controlled airplanes, four wheeling, mountain biking, and snowmobiling. Dave has been teaching electronics since 1976. He earned his bachelor's and master's degrees in technology education from Brigham Young University.

# SPACESHIP ONE:

## Effective

by Brian Mork



***“Los Angeles center, United 522 has traffic descending through FL420.”***

***“Roger 522, Duster34 is deorbital traffic, cleared to land #1 at Mojave Space Port.”***

This radio exchange is not that far off in the future! On June 21st, I had the opportunity to attend the first public launch of Scaled Composites' space flying aircraft, SpaceShip One. On October 4, 2004, they won the Ansari XPrize by successfully launching into space from the Mojave, CA Spaceport twice in the span of five days. They were particularly effective in their technical and program goals.

At the same time, my high school-aged children have reached the stage where they're exploring the world around them, searching for what they will do with their lives. I realize that, during these years, vectors are set for the rest of life and I know they're affected by many inputs. In this way, the efforts of the SpaceShip One team were more than effective. They were also affective.

This article is divided into two sections. "Effective" is about SpaceShip One as they launched it into space. The last part of this article — "Affective" — is from my kids' perspective as their interests launch into life.

### Why Such Interest?

In 1992, I first applied to the NASA astronaut program. That year and every two years after that, I continued to apply. In 2000, I made it to the final 120 of over 3,000 applicants. I was invited for the much discussed one-week interview, but — in the end — I wasn't selected. I may not be the "right stuff," but I've always wanted to be involved with space exploration.

Apparently, I'm not the only one. Paul Allen — the



# SPACESHIP ONE: Effective



SPACESHIP ONE GLIDES DOWN FOR APPROACH TO THE MOJAVE SPACE PORT.

“other” Microsoft guy — has invested in many venues since the late 1980s. To answer the XPrize challenge, he funded a \$20 million effort of Burt Rutan’s company — Scaled Composites — to design, build, and operate an aerospace vehicle capable of reaching space. The XPrize Foundation provided additional motivation in the form of a \$10 million prize that’s been out on the street for a number of years.

Burt Rutan began contributing to the aircraft industry in the late 1970s. His Varieze and Longez were the first popular composite-constructed, home-built aircraft and many are still flying. He left the home-built market for liability reasons and designed at least one model for the Beech aircraft company. Now, it seems he is content working on privately funded efforts — still specializing in composite structures.

## Simply Effective

About 3 A.M. on June 21st, I headed to the Mojave, CA airport to watch Scaled Composites put the first civil-

THE WHITE KNIGHT TURBOJET AIRCRAFT CLIMBS OVER THE MOJAVE DESERT WITH SPACESHIP ONE ATTACHED BELOW.



ian pilot into space from what has now been christened the “Mojave Spaceport” — our nation’s first inland space launch facility. The events and atmosphere of the morning had a casual sense that betrayed the significance of the accomplishment. All the launch pads, monstrous rockets, bureaucracy, space suits, scary heat shields, and hundreds of engineers were simply not there. It begs the question why didn’t our nation do it the simple way from the beginning.

Yet, maybe our nation did. I’ve toured strategic missile silos that held off Russia during the Cold War. I’ve climbed to the top of Cape Canaveral launch gantries. I’ve leaned into, touched, and communed with an Atlas rocket launch stack as it swayed in the Florida winds before it sent “our baby” (a satellite) on a one-way trip into space. Yet, compared to all of that magnificence, the most memorable impression is of the time I visited the launch pad where Alan Shepard piloted the first US manned space flight, MR3. In 1961, he was hurled into space with a Redstone rocket from a launch pad that is reminiscent of a large urban basketball court. There was a concrete wall to hide behind and amazingly little else. You need to see the photo to appreciate where our nation’s space program began: [www.apolloexplorer.co.uk/photo/html/mr3/10073513.htm](http://www.apolloexplorer.co.uk/photo/html/mr3/10073513.htm)

To be fair, reaching the edge of space is very different than keeping people there. The energy expended in the launch of SS1 put them in space briefly. The energy they needed to accomplish this didn’t even approach that required to put them in orbit. Loosely put, the additional energy required would accelerate them from about zero horizontal velocity at altitude to a speed of 17,500 mph. In other words, the energy required to orbit is significantly greater and does not even factor in the additional required systems and infrastructure to support the operations.

Modern NASA human space flight launches have a lot more overhead and infrastructure. Recently, I was an on-scene commander for emergency landing contingencies of the Space Shuttle at Edwards Air Force Base. I’m one piece in a pretty extensive program at Edwards and we’re only one of many launch recovery sites. Operating a space flight is a pervasive program that reaches out and touches thousands of people.

I know it’s all there for a reason. I can personally explain maybe 60 to 70 percent of it. I would defend more than half. Yet, at times, I exhale deeply, frustrated at all the bureaucratic quagmire and can think nothing more than, “It’s killing us. We’re buried in bureaucracy. I don’t know how to change it. We could do so much more!” I don’t have a comprehensive enough perspective to understand how to get out of the situation. Sometimes, it’s not the plan to understand, but to simply do. In the case of SpaceShip One, Mojave Airport personnel, Kern County, and Scaled Composites, they did. It’s that simple.

# SPACESHIP ONE: Effective

## Spectator Log

At 4:18 A.M., I departed from home with kids in tow. By 4:45, we were parked just outside the airport gates. Naively, we walked in, headed to the control tower, and claimed a few square feet of asphalt by 5:30. Isn't everything at the control tower?! We counted perhaps 500 people, indicating a decent showing, but not a magnificent one. I concluded that Mojave is farther off the beaten path than I realized. Days later, we learned the public viewing area was more to the south, where thousands of people were in attendance. We had unknowingly stumbled into the VIP viewing section.

At 6:38 A.M., the White Knight aircraft, with SpaceShip One in carriage below, taxied to the southeast for takeoff. A minute or two later, the Beechcraft Starship followed behind to do a photo chase as White Knight climbed to the release altitude of approximately 50,000 feet. The Starship departed first, but they were both airborne by 6:47 A.M.

The high altitude chase ship — a Dornier Alpha jet — taxied past about 20 minutes after the first pair, destined to catch SpaceShip One gliding back to Earth at the highest reaches of altitude that would still allow an air-breathing engine to operate.

The Extra 300 acrobatic chase plane also departed and started a climb to altitude, prepared to accompany SpaceShip One during the middle and later portions of the glide back to Earth. I was distracted, setting frequencies in a portable scanner.

Then, the waiting began — many minutes, seemingly an hour or so. As is true most of the daylight hours in Mojave, the sky was a beautiful blue and contrails were visible through much of the flight. At 7:50 A.M., they reached the 50,000 target release altitude, SpaceShip One separated from the White Knight mothership, and Mike Melville fired the rocket engine.

When the hybrid rocket fired, it left a vertical arch in the sky. I stepped behind the shadow of the control tower and clicked a few pictures as they headed to a 65 km final altitude. If you followed the story via the news media, you've heard about the rolls that left a wiggle in the contrail and concerned many people. Post flight analysis on their XPlane-based flight simulator showed that pulling back a bit too much in the early part of the climb required a gentle push in the later part of the climb that put the plane in a low angle of attack condition that was not expected. This was easy to fix for the next flight, so no adjustment was made to the schedule for the two competition flights on September 29 and October 4.

There were no sounds other than the crackle on my scanner until the double sonic boom announced that SpaceShip One was back in the atmosphere. The space capsule had rotated the wings to a high drag configuration for reentry. During the glide back to thicker air, the wings were rotated back to a glide configuration.



AT THE END OF ITS HISTORICAL FLIGHT, SPACESHIP ONE IS ON FINAL APPROACH TO LAND.

Three chase ships picked up the space craft as it descended to lower altitudes. The red and black Extra escorted Mike Melville through the final approach to Runway 30, with a full stop landing 87 minutes after he departed under the White Knight aircraft. The wooden skid and small brakes on the main wheels brought him to a stop with plenty of runway remaining.

A white pickup truck with a dropped tailgate towed SS1 back to the spectators, where dignitaries gave a short news conference. Three other aircraft (Starship, Extra, and AlphaJet) did a three ship fly-by and then peeled off to land one after the other.

On September 29, the Scaled Composite crew did the same thing — only 23 minutes later in the day, according to my watch. By the prize-winning flight of October 4, repeated viewers picked up on the rhythm of a Mojave Space Port launch. The news media was referring to the “traditional hand wave” while taxiing to take off. Mike Melville was the “veteran astronaut” as Brian Binnie

PAUL ALLEN, MIKE MELVILLE, AND BURT RUTAN AFTER THE FIRST PRIVATE, MANNED SPACE FLIGHT.





# SPACESHIP ONE: Effective



MISSION CONTROL AT SCALED COMPOSITES DURING FLIGHTS WAS SPARTAN.

attained his astronaut wings.

Complete statistics on the first space mission can be seen at [http://en.wikipedia.org/wiki/SpaceShip One\\_flight\\_15P](http://en.wikipedia.org/wiki/SpaceShip_One_flight_15P)

The third space flight of SpaceShip One attained a maximum altitude of 377,591 feet, breaking the NASA X15's 41-year-old record. Details on the two Xprize flights can be seen by changing the last part of the above URL to 16P or 17P.

## Safety Style

Ask yourself why there are no space suits associated with SpaceShip One. It's not as if there was no threat. At 50,000 feet, a cabin leak, structural issue, or pressure failure is a big deal. Useful consciousness at 35,000 feet is less than a minute and they went well above that altitude. They side-stepped many of those issues by not having

NEWS MEDIA WAS EVERYWHERE — NOT JUST MAJOR TELEVISION AND CABLE CHANNELS, BUT REPRESENTATIVES FROM MANY PRINT OUTLETS, RADIO STATIONS, AND DOCUMENTARIES WERE ALSO IN ATTENDANCE.



any “active pressure control” due to inflow and outflow valves. They simply buttoned up the capsule, slowly released oxygen from a small bottle, and circulated air to remove moisture and carbon dioxide. In this environment, the SpaceShip One crew had no personal wear backup. This presumed safety requirement was simply deleted. The difference caught my attention.

I spend hours of my professional life at Edwards Air Force Base doing technical and safety reviews for premier military test programs done nowhere else in the world. I would not choose to give up anything I sense as safe. However, I've come to believe it's a critical balance. “Safety first,” at times, competes with “mission first.” For example, what's the incremental cost of preventing the last victim of an earthquake disaster? If we invest for that goal, it simply costs too much in other ways and people die, regardless. Look up the statistics about dying as a soldier in Iraq compared to the same number of people stationed at home. It will surprise you. During Desert Storm in the early 1990s, it was statistically safer to be deployed to the war.

Sometimes, things break and people die. During my years at the Air Force Academy, I had a good Canadian friend who loved the space industry. He ran a private business and did international consulting. We struck up a friendship. I was honored when he asked me to help with educational entrepreneurial efforts and research grants. At the time, my duties to family and military prevented this, but I looked to future possibilities. Three years later, I received an email from another satellite team member letting me know my friend had died. One day at his desk, his heart failed. That quickly, dreams for space flight were cut short.

My first full-time aircraft commander, back in the days when Strategic Air Command had fixed crew composition, was another friend of mine. Deployed, we pondered about the job of an astronaut. I applied. He applied. He was selected. He died in 2003, when Columbia disintegrated over the southwest US. All the preventative safety efforts of NASA didn't save him.

Sometimes simply delaying is enough to seriously impact a test program or “cause death” by exposing the process to the time statistics of accidents and peoples'

PHOTOS COURTESY OF SCALED COMPOSITES, LLC.



# SPACESHIP ONE: Effective

deaths. As the young engineers of the 1960s retire, our government is coming up against a shortage of experience in aerospace disciplines. Delaying efforts may mean they simply won't be undertaken or they'll be done less safe, simply because all the intellectual property of knowledge and experience has retired or died.

In my opinion, when the safety effort of any program has reduced risks to approach those of simple living, that's enough. Incurring more safety limits either slows the program unnecessarily or, in fact, mitigates safety in layers of bureaucracy. Also, when safety concerns slow things down to the point where people leave the program, people retire, and the program goes nowhere, it's a losing spiral.

The culture at Scaled Composites shows some features that make me think they've institutionalized a more healthy view of safety. Let me be clear: They don't do things that are unsafe. At the same time, they stick to simplicity and directness in their engineering.

Finding a new balance shows up in other ways, too. For example, their mission control room to send someone into space looks very reminiscent of Amateur Radio Field Day competitions I've done. It has Yaesu antenna controllers, Icom radios, and Kenwood handhelds spread across a room of tables. Even a few FMR radios picked up from the local retail outlet show up. They have a dozen or so computer screens and a window overlooking the aircraft ramp. Combined with the capabilities of the Internet, it's probably good enough to do a global mission.

Whether it's safety, equipment, or methods, they appear to draw a balanced line and excel at finishing things. If the existing aerospace establishment isn't recognizing the difference, it's because they're not paying attention. I'm not saying nothing bad can happen. If they keep pressing boundaries, some may even die, but at least they died accomplishing something rather than nothing.

Accomplishing something is of value and it's my opinion that we need to swing the pendulum of our society in that direction. I'm buried in the depths of big government acquisition programs and I'm confident many things can be done better than they are. I'm not so confident I can change anything, but the next generation may.

It's encouraging to watch my kids, who have noticed the thrill of this activity in their own backyard. They've gone to the SpaceShip One launches and they've seen what can be done rather than all the reasons things don't get done. Surrounded by the events at Mojave Space Port, my children were intrigued enough to enter the engineering



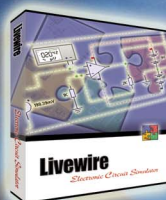
WE COUNTED PERHAPS 500 PEOPLE IN THE VIP VIEWING AREA, COMPARED TO THE THOUSANDS OF VIEWERS IN THE GENERAL ADMISSION AREA.

curriculum at Mojave High School and, this year, put in extra effort to compete in airplane design contests and robotic competitions. Two days after Rutan's success, my son Elliot's team had a success of their own, tagging two first place awards in a glider competition. The baton passes. We have so much yet to do .... **NV**

## ABOUT THE AUTHOR

Brian Mork, Ph.D., is an engineer, scientist, and pilot. He works as a directed energy systems engineer and on the staff of the USAF Test Pilot School. He has experience in data collection, industrial control, classified aerospace systems, and has 2,500+ hrs in a variety of civilian and military aircraft. Contact him at [feedback@increa.com](mailto:feedback@increa.com) or visit [www.increa.com](http://www.increa.com)

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# SPACESHIP ONE: Affective

by Elliot Mark

I recently had the opportunity to attend the launch of SpaceShip One through a program at my high school, Mojave High School's Engineering Academy. The morning of the launch, I was watching the contrails of the space ship and I it made me think that the Anisari Xprize was very similar to a competition I was involved with. Last year, I was part of a school team in an attempt to win the Kern County Air Show Aerospace Science Competition; the goal was to get young people interested in aerospace.

A transition between teachers in the Engineering Academy left me with the task of creating a new team to compete in 2004. My first task was to balance the team with several different strengths. I decided we needed a mixture of people trying to get everything perfect and people just doing something and seeing if it worked. Most of the team was already familiar with the order of building and testing new airplanes because we live close to Edwards Air Force Base, the home of Air Force testing for new planes. We followed a broad, three-step process: First, design a plane that should theoretically work, then use skills necessary to create it according to plan, and, lastly, test it. Of course, if the testing did not follow the predicted results, we went back to the drawing board.

The main goal of the competition was to create a glider that could carry two US mint quarters for a maximum hang time. It would be judged by multiplying weight by hang time. Two other categories were pure hang time and best documented design. The grand prize was \$1,500.00. Second prize was \$1,000.00 and third was \$500.00. Best hang time and best docu-

mented would win \$250.00 each.

Early on, I knew we needed someone with experience in this field to give us some advice and direction. My teacher, Mrs. Boyd, and I arranged for an expert to come during school and help us with the design of our glider. Mr. Matt GeWayne, our mentor, brought designs on the first visit and we discussed how we could pick the best design and tweak it to fit our needs.

After Mr. GeWayne left, we built several different gliders roughly according to the plans he brought. The second time Mr. GeWayne visited our school, he taught us how to trim each glider so it would fly without climbing too steeply or diving into the dirt. The day he was there, we got three gliders flying.

Immediately, we could see that the biggest one we made was not going to work because the launch mechanism for the gliders could not give it enough power. Two smaller ones were working really well, but one had longer flight times.

After flying each one, we could analyze what was wrong with each glider; it was too heavy, too fragile, or just not air-worthy. With that knowledge, we started to build our next round of gliders. We built one very small one, knowing that it could use the power from the launcher more efficiently. The medium-sized one centered on a mixture of using the power efficiently and keeping the weight down. The largest one was fairly heavy, but could still fly very well.

One reason we chose to use the heavy one in the competition was that it needed to fly only half the time due to the scoring formula being used. Our medium glider was getting more hang time, but not a higher overall score because it was not

very heavy.

The day of the competition was nerve-racking. I knew we had a glider that could easily compete with last year's gliders, but I did not know what to expect this year. After seeing several planes launch, I knew we were going to be competitive if we had a good flight.

Each team had three launches. The first one's score was multiplied by one, the second by 1.1, and the third by 1.15. The reasoning behind this scale was to promote endurance and consistency in the gliders.

In the first round, we had a launch that could not have gone better; the glider jumped into the air, curved around, and started to gently glide down. The second launch was a little better because our launching person, Daniel Loehrer, was perfecting the technique of launching it a little more by adjusting the climb angle and tilt of the launcher. We could not have asked for a better third flight! It quickly climbed off of the launch mechanism and curved around. As the crowd cheered, it slowly lost altitude — clearly flying and not dive-bombing like last year.

Our team huddled together, anxious to get the results of the last flight and the unofficial announcement of the winners. After confirming the weight of the top five gliders, it was announced that our school, Mojave High, had won the grand prize, along with best hang time! We were all very elated during several interviews by local TV and radio stations.

As I watched SpaceShip One land safely to win the \$10 million Xprize, I realized what we were doing was the exact same thing on a smaller scale. The work was intriguing as we designed our plane with help, learned techniques about how to build with balsa, and gained valuable knowledge through testing and flying. We had designed an aircraft according to a set of rules and won. Someday, I hope to join the rest of the world's engineers to help create the next contribution to science.

**The Mojave High School glider competition team took first place in two of three categories in their competition two days after SpaceShip One won the X-Prize.**



**Generations of people before have imagined the impossible and turned it into the possible. That's the kind of inspiration and motivation Scaled Composite's SpaceShip One accomplishes.**



## About Elliot & Tori

Two of Brian's children, Elliot and Tori, are currently juniors at Mojave High School. Elliot is interested in engineering, golf, and business education. Tori enjoys biology, foreign languages, and graphic arts. Both are entered in a USA First robotic competition scheduled for Spring of 2005.

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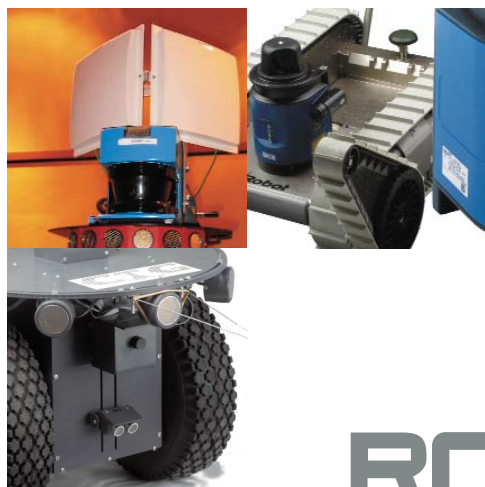


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Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

# Stamp Applications

## Ping ... I See You

*I used to work for a man named Bob who insisted — and quite frequently — that most of us needed to be exposed to the same piece of information five to seven times before that information could be absorbed. I didn't always agree with Bob's philosophy, but in case he was right, I thought we'd work through the mysteries of conditional compilation again. Conditional compilation is worth mastering; it allows us to write one program that will work on nearly any BASIC Stamp module.*

**M**aybe I'm just taking things for granted. Being on "the inside" and close to the development of the BASIC Stamp IDE, I completely understand conditional compilation and how to take advantage of it. Apparently, however, I haven't done a very good job getting the word out, as I keep getting a lot of questions on this subject. So, I'm going to try again.

Let's start from the beginning. Why should we even bother with conditional compilation? Well, it depends,

really. If we're going to write a program that will *never* (yeah, right ...) need to run on another BS2 family module, then we don't need to bother. What if, however, we want to share our cool program with a friend who uses a different module? What if we wrote our program for the BS2 and our friend is using a BS2sx? Most programs will run without change, but the use of certain PBASIC keywords will require the code to be updated to run properly on the BS2sx. By using conditional compilation up front, we can save ourselves and others trouble later.

### Ping ... Ping ...

Before getting into the gritty details, let's have a little bit of fun with a simple program that actually uses conditional compilation. Sonic range finding modules are very popular with robotics builders and experimenters, and Parallax has recently created a new module called Ping that makes sonar range finding pretty easy. Honestly, I really like the Ping sensor, as it requires only one I/O pin, works with any BASIC Stamp module, and is very low cost.

As you can see by Figure 1, the connection is a no-brainer — connect power (+5 volts), ground (Vss), and a signal line to a free BASIC Stamp pin. With the Ping module, the I/O pin serves as both the trigger output and the echo input. Have a look at Figure 2 and we'll walk through how it works.

Initially, the trigger pin is made an output and a short pulse (five to 10  $\mu$ S) is used to trigger the Ping (we'll use **PULSOUT** to generate the trigger). The next step is what allows it to be used with any BASIC Stamp. The Ping module delays the trigger to the sonic transmitter element for 500 microseconds. This allows the BASIC Stamp to load the next instruction (**PULSIN**) and be ready for the return echo. Once the echo pulse is measured, a bit of math is used to convert the pulse width to distance.

Figure 1. Ping Connections.

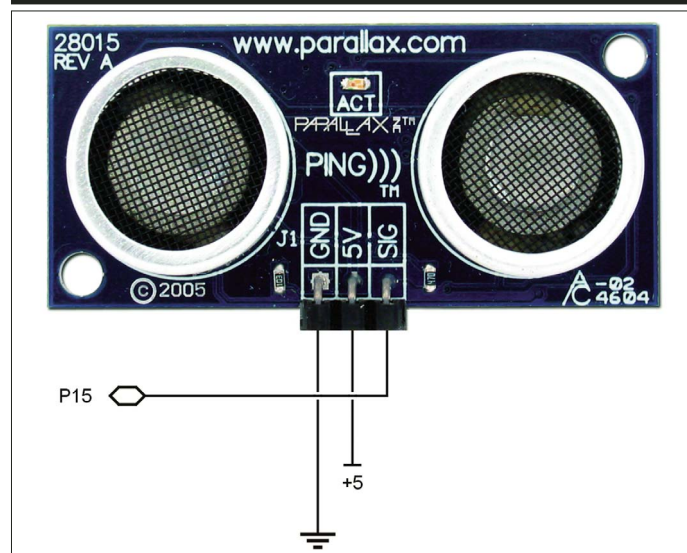
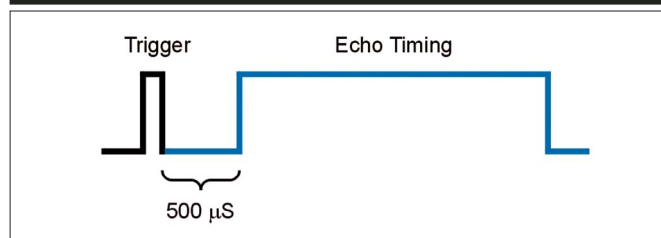


Figure 2. Ping Signaling.



Let's look at the subroutine that handles the Ping sensor:

```
Get_Sonar:
  Ping = 0
  PULSOUT Ping, Trigger
  PULSIN Ping, 1, rawDist
  rawDist = rawDist * Scale
  rawDist = rawDist / 2
  RETURN
```

The code starts by making the output bit of the trigger pin 0, and the reason for this is that **PULSOUT** makes the trigger pin an output, toggles its state, delays, and then toggles that pin back to the original state. Since the Ping module is looking for a low-high-low pulse to trigger the measurement, presetting the pin to 0 makes this happen.

After the trigger is sent, **PULSIN** is used to measure the width of the echo pulse. As I stated earlier, the 500 microsecond delay in the Ping allows **PULSIN** to get loaded and ready. There is no danger of **PULSIN** timing out, as even the BS2p (fastest BASIC Stamp module) won't time out for about 49 milliseconds. For you clever readers who are wondering what happens if we forget to make the signal pin an input after the trigger pulse ... no worries, there is protection on the Ping sensor so that no harm is done if both sides are trying to drive the signal line.

Now, we have to get back to that pesky conditional compilation stuff. Remember that the various BASIC Stamp modules run at different speeds and — with some instructions — the speed differences give us different resolutions. Let's look at the units returned by **PULSIN**:

BS2, BS2e	2.00 ms
BS2sx, BS2p	0.80 ms
BS2pe	1.88 ms

Let's see how conditional compilation lets us handle the differences in the various modules:

```
#SELECT $STAMP
#CASE BS2, BS2E
  Scale CON $200
#CASE BS2SX, BS2P
  Scale CON $0CD
#CASE BS2PE
  Scale CON $1E1
#ENDSELECT
```

The instructions prefaced with “#” are used in the conditional compilation process. These instructions actually get processed before our program is tokenized. This allows constant values and even bits of code we choose to be included in the program based on the BASIC Stamp module in use. So, using the code above, if a stock BS2 module is installed, the constant — called Scale — will have the value \$200. If we unplug the BS2 and swap in a BS2p, then we will program the module Scale to have the value \$0CD.

Let's get back to the program; we'll cover more condi-

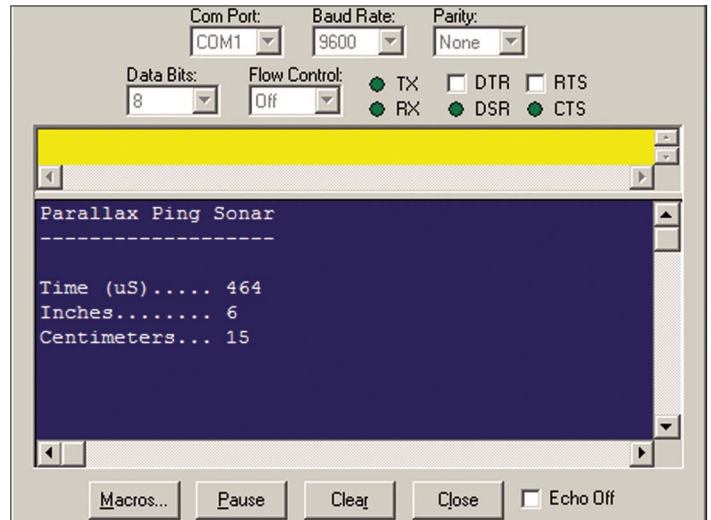


Figure 3. Ping Terminal Output.

tional compilation later. The raw value from **PULSIN** is converted to units of one microsecond with this line of code:

```
rawDist = rawDist * Scale
```

We're forced to use the “\*/” (star-slash) operator to

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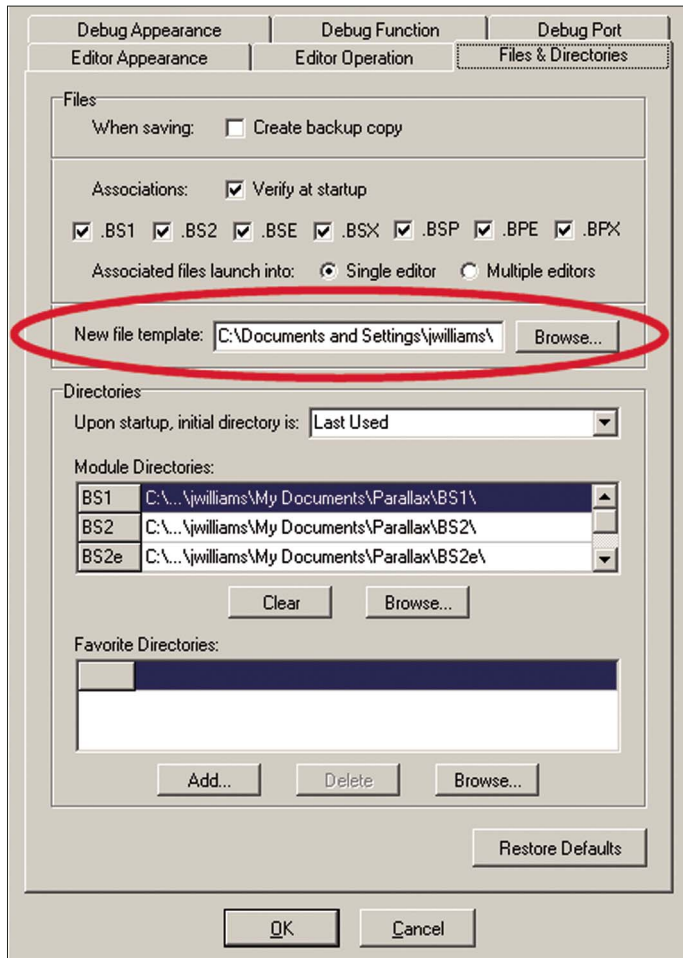


Figure 4. IDE Prefs.

account for the fractional units when using the BS2sx, BS2p, or BS2pe. For review, “\*/” works like multiplication, but in units of 1/256. To determine the various values for Scale, we multiply the **PULSIN** units by 256 and take the (rounded) integer result. Things work out like this:

BS2, BS2e	INT(2.00 x 256) = 512 (\$200)
BS2sx, BS2p	INT(0.80 x 256) = 205 (\$0CD)
BS2pe	INT(1.88 x 256) = 481 (\$1E1)

I prefer to use hex notation for values that are used with “\*/”, as the upper byte represents the whole portion of the value and the lower byte relates the fractional portion (in units of 1/256). The pulse is measured and converted to microseconds, and before returning to the caller, we’ll divide the raw value by two. Why? Well, the pulse we’ve just measured actually accounts for the distance to and from the target — actually twice as wide as we need, hence the division.

Now, to convert to distance: At sea level and room temperature, we assume that sound travels at about 1,130 feet per second, and by multiplying by 12, we get 13,560 inches per second. By taking the reciprocal, we find that it takes about 73.746 microseconds for sound to travel

one inch. For those who prefer the metric system, we can convert 13,560 inches to 34,442 centimeters and a timing value of 29.034 microseconds to travel 1 centimeter.

For our conversion code, we’ll use the other fraction math operator, “\*\*\*”. This is similar to “\*/”, except that it uses units of 1/65,536. This means that, in the 16-bit values used by the BASIC Stamp, we can use it to multiply by fractional values of less than one. In our program, we can convert 73.746 microseconds to a constant value like this:

$$1 / 73.746 \rightarrow \text{INT}(0.01356 \times 65536) = 889 (\$379)$$

With that, we can look at the rest of the program:

```
Reset:
  DEBUG CLS,
    "Parallax Ping Sonar", CR,
    "-----", CR,
    CR,
    "Time (uS).....", CR,
    "Inches.....", CR,
    "Centimeters..."

Main:
  DO
    GOSUB Get_Sonar
    inches = rawDist ** RawToIn
    cm = rawDist ** RawToCm

    DEBUG CRSRXY, 15, 3,
      DEC rawDist, CLREOL
    DEBUG CRSRXY, 15, 4,
      DEC inches, CLREOL
    DEBUG CRSRXY, 15, 5,
      DEC cm, CLREOL

    PAUSE 100
  LOOP
END
```

The Reset section simply sets up the text portion of the Debug Terminal window and, in Main, we measure the distance, do the conversions, and display the results. Figure 3 shows the output of the program.

## Stamping Under Any Condition

Time to get back to conditional compilation. While most PBASIC instructions don’t require parameter changes when moving from one module to another, there are a few that do:

<b>COUNT</b>	Units for Duration of COUNT window
<b>DTMFOUT</b>	Units for OnTime
<b>FREQOUT</b>	Units for Duration, Freq1, and Freq2
<b>PULSIN</b>	Units for Variable (measured pulse)
<b>PULSOUT</b>	Units for Duration
<b>PWM</b>	Units for Duration
<b>RCTIME</b>	Units for Variable (measured RC delay)
<b>SERIN</b>	Units in Timeout, value of Baudmode
<b>SEROUT</b>	Units in Pace and Timeout, value of Baudmode

The most common issue among BASIC Stamp users when moving from module to module is with **SERIN** and **SEROUT**. So common are these instructions that I have built the following section into my default programming template:

```
#SELECT $STAMP
#CASE BS2, BS2E, BS2PE
  T1200    CON    813
  T2400    CON    396
  T4800    CON    188
  T9600    CON    84
  T19K2    CON    32
  TMidI    CON    12
  T38K4    CON    6
#CASE BS2SX, BS2P
  T1200    CON    2063
  T2400    CON    1021
  T4800    CON    500
  T9600    CON    240
  T19K2    CON    110
  TMidI    CON    60
  T38K4    CON    45
#ENDSELECT

SevenBit    CON    $2000
Inverted     CON    $4000
Open        CON    $8000

Baud         CON    T9600
```

If **SERIN** and **SEROUT** aren't used by a given program, there is no harm done — and it's far handier to have constants predefined than to have to look them up. This gives me the opportunity to bring up another programming tip. I frequently get code that looks like this:

```
SEROUT 15, 16468, [DEC temperature]
```

which is followed by the complaint, "Jon, this used to work with my BS2, but now it doesn't work with my BS2sx."

By now, I'm sure you see that the reason is obvious: by changing from the BS2 to a BS2sx, we are forced to update the baudmode parameter of **SEROUT**. The problem can be averted by using the conditional section above and changing the Baud definition as follows:

```
Baud         CON    Inverted + T9600
```

While we're cleaning up the code to make it easier to maintain, let's give a definition to P15 so that we know the serial output is going to a serial LCD:

```
Lcd          PIN    15
```

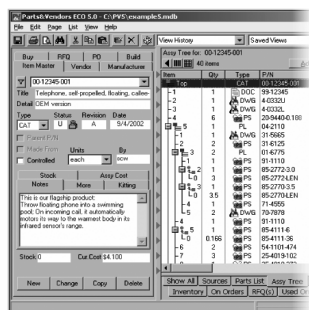
Now, the corrected code becomes:

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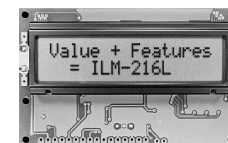
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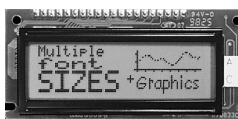
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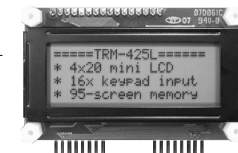
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```
SEROUT Lcd, Baud, [DEC temperature]
```

Where else might conditional compilation come in handy? How about program debugging? There is an instruction called **#DEFINE** that can help in this regard. For example:

```
#DEFINE DebugOn = 1
```

While developing and troubleshooting an application, we can do this:

```
#IF DebugOn #THEN
  DEBUG "Value = ", DEC value, CR
#ENDIF
```

in as many places in the program as we need.

Once the program is fully tested and working as desired, changing the DebugOn definition to zero will prevent the **DEBUG** statements in the **#IF-#THEN** section(s) from executing. It's important to understand that conditional definitions are either defined (not zero) or not. In our example above, we could, in fact, remove the **#DEFINE** DebugOn line without harm to the program. When the compiler encounters a conditional block (like **#IF-#THEN**) with an undefined symbol, the section is skipped. I don't recommend this, however, as it can lead to confusion if someone else reads code from which we've removed conditional symbol definitions. It is best to disable the conditional symbol by redefining it as zero.

Another good use of conditional definitions is variable conservation. In our sonar program, for example, practical use would usually not require both standard and metric units. We could do this:

```
#DEFINE MetricUnits = 1

and ...

#IF MetricUnits #THEN
  distance = rawDist ** RawToCm
#ELSE
  distance = rawDist ** RawToIn
#ENDIF
```

Finally, what about features that exist in the newer BASIC Stamp modules that do not exist in the older ones, LCD control, for example. Well, we can deal with that, too.

There was a project we did some time back that involved the Parallax LCD Terminal AppMod and took advantage of conditional compilation. A program can check for the availability of built-in LCD commands like this:

```
#DEFINE LcdReady = ($STAMP >= BS2P)
```

We can now put this definition to use in the following manner:

```
LCD_Command:
  #IF LcdReady #THEN
    LCDCMD E, char
    RETURN
  #ELSE
    LOW RS
    GOTO LCD_Write
  #ENDIF

LCD_Write:
  #IF LcdReady #THEN
    LCDOUT E, 0, [char]
  #ELSE
    LcdBusOut = char.HIGHNIB
    PULSOUT E, 3
    LcdBusOut = char.LOWNIB
    PULSOUT E, 3
    HIGH RS
  #ENDIF
  RETURN
```

It does take a little bit of planning and extra work to implement conditional compilation, but I think you'll find it fairly easy to do in the end, in addition to being a big time-saver when it comes to moving code from one BASIC Stamp module to another.

## Installing a Template

Earlier, I mentioned my default template and its use of serial baudmode values. I've included a copy of my template in the project files at **www.nutsvolts.com**. Let me share a tip that may not be obvious. You can have the BASIC Stamp IDE load this template each time you select File / New (or the New icon from the toolbar).

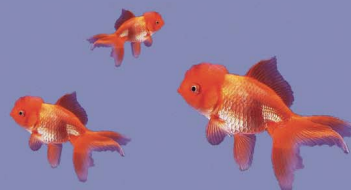
Start by copying the template (template.bs2) to a convenient location. Then, open the Preferences dialog (Edit / Preferences), select the Files & Directories tab, and click on the Browse button located next to the New File Template field. In the Open dialog, navigate to the location where you copied the template file, select it, and then click on Open. Lock in the setting by clicking OK at the bottom of the Preferences dialog. I find the template helps keep my programs organized and I'm sure it will work for you, too — if it doesn't quite do so, modify it until it does!

Until next time, then, Happy Stamping. **NV**

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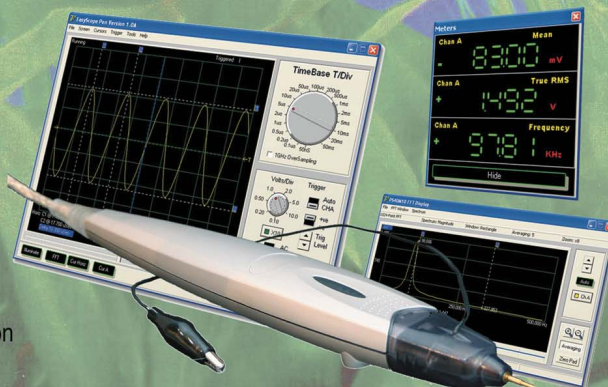
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Approaching the Final Frontier

# Near Space

## Updates on Modifying Cameras for Digital Control

I've been experimenting with cameras since my last column, and this month, I have some updates on three camera topics: modifying other cameras, adjusting the focus on fixed focused cameras, and IR imaging.

### Modifying Some Other Cameras

Be warned that modifying cameras voids their warranty, which is one of my favorite activities. To date, I've used cameras with autofocus on my balloons, and my favorite example is the Canon Elph (an APS film camera). This is the camera that has recorded my most spectacular photographs, and I owe Bill All (NOKKM) a thanks for bringing this camera to my attention. My latest camera is a four megapixel digital camera — the Concord 4060 AF, and I owe Kyle Thorson (KB5TSS) a thanks for bringing that one to my attention.

Cameras like these use a two-position micro-push-button switch for the shutter, and you've probably seen these switches as the reset switches in Parallax's Board of Education or on a VCR PCB (Printed Circuit Board — if you've ever taken one of these apart). The switch measures about 1/4 inch square and has four PCB mount pins. The first depress position on the camera shutter switch focuses the camera and the fully depressed position operates the camera's shutter. (In some cameras, the fully depressed position also focuses the camera.) When you push the shutter button on these cameras, the switch shorts the camera's focus or shutter circuitry to ground.

The plan of attack to modify these cameras is to first open the camera, identify the function of the shutter switch's pins, solder wires to them, and then close up the case.

First, remove the batteries and then open the camera case. Be sure to store the tiny screws where they will not get lost and write down which screws go into which holes if you discover the screws are different lengths. Now that the camera is opened, be especially careful that you don't touch the flash capacitor.

Make a quick drawing of the micro-push-button switch and its pins, as it's always a good idea to document your findings. Set a Digital Multimeter (DMM) to continuity check and locate the pin on the micro-push-button switch that is connected to

ground. Connect one DMM lead to the negative spring contact in the battery case and start probing each micro-push-button switch pin until the DMM rings. Check all the pins, as you may find that two micro-push-button switch pins are connected to ground.

After locating the ground pin(s), reassemble the camera case just far enough so you can load batteries back into it. With a short length of thin gauge wire, carefully try shorting the remaining pins to the ground pin and observe the results. When you do this, you want to find the pin that makes the camera take a photograph. Don't point the camera at yourself during your test, unless you like being flashed at close range with a strobe. Again, document your results.

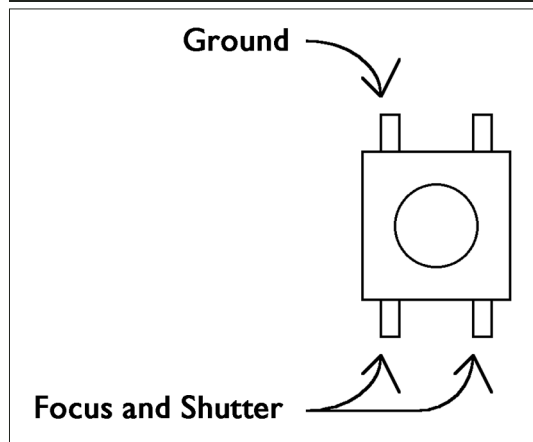
### Two Specific Camera Examples

Figure 1 shows the pin locations and functions for the Canon Elph and Concord 4060 AF.

I don't recall having trouble opening the Elph case, but I do know that the hole in the case of the shutter button is too small to work the soldering iron through. You'll need to fully open the case to get to the shutter switch.

I started my experimenting with the Concord by first visiting Kyle Thorson's website — [www.webpages.uidaho.edu/~thor7358/hiball/concord/](http://www.webpages.uidaho.edu/~thor7358/hiball/concord/) I found the camera case a little difficult to open. The buttons over the slide switches are latched together, so you need to pull on the button a bit to separate it from

**Figure 1.** This is a top view of the shutter button. The front of the camera is located at the bottom of the image.



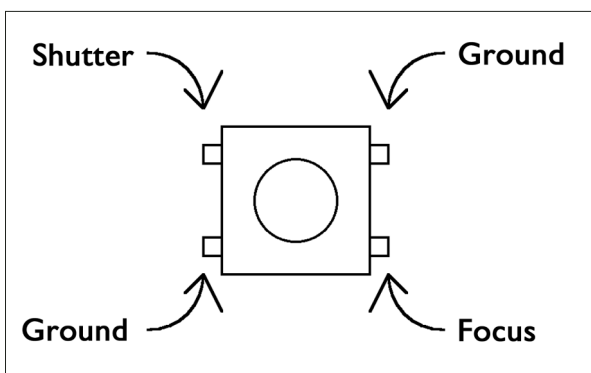
the slide switch. I only opened up the camera far enough to pull the shutter button out of the case. The hole in the case for the shutter button is large enough to get a solder iron through. I suspect it'll be easier to cut out the button instead of trying to open the camera case. From my experiments, I have found that you only need to solder the wires to the Common (ground) pin and the Take pin. I have found no reason to use the switch's Focus pin.

## Making the Connections

Now that the ground and shutter pins are identified, solder wires to the micro-push-button switch's solder pads, and we'll call the wires the shutter cable. Shut off the camera, remove its batteries, and open the camera case again.

Cut two lengths of thin gauge, stranded wire (I use about a AWG Number 30 wire cut to about nine inches long). I recommend making the wire that's connected to the ground pin green or black in color so you'll know its function once the camera case is closed. Strip about an 1/8 inch of the insulation from one end of each wire. Tin the bare ends, and trim the bare ends back down to 1/8 inch if the heat has melted back the insulation. Tin the solder pads of the micro-push-button switch, and hold the first wire to a switch pad and heat the contact between the tinned wire and the switch pad. The solder on both the wire and the pad should fuse them together. Repeat this with the second switch pin.

Decide at this point if you want to modify the camera solely for digital control or if you want to retain manual control of the camera. If you want only digital control, then you can remove the cover over the shutter but-



**Figure 2.** The pins on this switch are very tiny; solder them with care.

ton, since you won't be pressing it. If you still want to use the camera manually, then keep the plastic button cover in place and find a location in the camera case where you can drill a small hole to pass the shutter cable through. Find a location in the camera case that is close to the shutter button, drill the hole, then pass the shutter cable through it. You can now close up the camera case for the last time.

I prefer to terminate the shutter cable in a connector, rather than soldering the ends of the wires directly to a transistor switch. I have used Dean's plugs (the micro variety) and headers and receptacles like you find on servo cables. By terminating the shutter cable in a connector, you can position the camera outside of the near spacecraft while leaving the control electronics inside without having to drill a large hole through the wall of the near spacecraft. A terminated shutter cable is also more convenient if you decide to modify the camera for dual use (in which case, you'll own a camera with a pigtail).

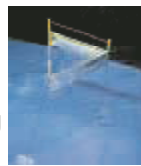
To prevent the shutter cable from being pulled off the micro-push-button switch, you need to add strain relief to the shutter cable. I've done this by either hot gluing the shutter cable to the camera case (do not hot glue the wires to the camera's PCB) or, preferably, by zip-tying the shutter cable to the camera case where the camera strap is attached.

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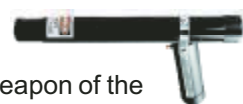


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**Figure 3.** An image with the IR blocking filter removed and the Pencam refocused.



**Figure 4.** An image with the IR blocking filter in place.

## Adding Digital Control

You've now completed the modification of your camera, but you can't operate it until you add digital control, which is a two step process. The first step is to make the transistor switch and the second is to add the control, either a microcontroller or a 555 timer circuit.

Refer to my article in the June 2004 issue of *SERVO Magazine* on adding a digital switch to an R/C transmitter. Specifically look at the diagram on page 23 and note that the

LED in my diagram is optional. I would only add it to the circuit as a troubleshooting tool. Be sure to connect the ground wire of the shutter cable to the emitter of the transistor. When you've completed the transistor switch circuit, protect it by covering it and its perf board in a length of heatshrink tubing.

## Operating the Camera

On a simple near spacecraft, I use a 555 timer circuit to operate the transistor switch. For advanced mis-

sions, I connect the transistor switch to my flight computer. Most cameras today shut down if they are not used within one minute. Keep this limitation in mind when deciding on how often to record images. When operating the camera by a 555 timer circuit, I use a 100 mF capacitor for C1, a 600K resistor for R1, and a 15K resistor for R2.

The resistors have a tighter tolerance than the capacitor does, so I pull resistors out of my junk pile

that are anywhere near the calculated values. A 555 timer circuit with these values produces a square wave that is high for 42 seconds and low for one second. The cameras I've used appear to tolerate a user who keeps pushing the shutter button this long.

## Fixed Focus Cameras

Now that I have completed my notes on modifying cameras for digital control, let's talk about fixed focus cameras and how they can be properly focused. The example I'll use is the PenCam I experimented with in the last column. The lens in the PenCam is preset to a focus of around 15 feet and not to infinity.

After launch, a camera on a balloon only sees a landscape that is truly infinitely far away. This means that inexpensive cameras with a fixed focus like the PenCam must be adjusted to record properly focused images.

Fortunately, the lens of my PenCam was set into a threaded barrel and I was able to rotate the lens barrel by hand.

To find the proper lens position, I placed one reference mark on the lens barrel and 16 (one every 45 degrees) on the housing that covers the CCD imager. I recorded several images outside my apartment with the lens barrel aligned with each of the reference marks on the CCD



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housing. After downloading the images, I selected the two best images. I then repeated the above process a second time; however, this time, I rotated the lens barrel one quarter of the way between the reference marks of the best two images before recording an image. After downloading the new images, I selected what appeared to be the best ones; the result was good enough that I really couldn't tell the difference between the two best images.

At that point, I called the focus good enough. The problem with finding the best image is that inexpensive, fixed focused cameras have such low resolution that it's difficult to distinguish between two close images.

While this process worked for my first PenCam, it didn't work for the second one. The lens barrel of the second PenCam was glued into

place so strongly that I couldn't twist the barrel without breaking the housing over the CCD imager. Instead of rotating the lens barrel, I tried sanding the bottom of the CCD housing in the hopes of lowering the height of the lens. I discovered that the CCD housing was set on top of the CCD imager cover slip. This meant that I couldn't lower the height of the lens by sanding; all I would do is create a gap between the legs of the CCD housing and the camera's PCB.

The last fixed focused camera I experimented with was the Vivitar ViviCam 3350. I discovered that it uses the same electronics as the PenCam does; it's just packaged in a differently shaped case.

## Infrared Images

Along with modifying cameras for digital control, I also found the

time to experiment with the PenCams and their IR filters. After removing the filter, I noticed that the new images had a red tint to them.

Foliage, for example, appeared red. I know that chlorophyll reflects some infrared along with green. It's my hope that I can compare visible and IR images taken from near space to detect any plants from near space. Figures 3 and 4 are two examples of images taken with the PenCam.

As you can see, there's some promise in using a digital camera to record IR images for comparison to visible images.

My research budget doesn't permit me to test other cameras at this time. However, I will eventually get around to other cameras. If you get a chance to modify any other cameras, please let me know what you've discovered and I'll share it with others. **NV**

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# In The Trenches

## Rules and Rule-Bound Behavior

**R**ules are part of everyday life and human nature. They are necessary and useful; however, rules can be confining, and this is especially true when rules are applied without any consideration for context. There are all types of rules: social, personal, business, technical, and biological. The important common aspect of these rules is that you don't have to understand them to obey or enforce them.

"I'm sorry, Sir. I can't refund your money on the software because the box has been opened. I'm sorry it didn't work as you expected and that your hard drive made a sound like a Yeti and then imploded, but it's store policy."

To most engineers, it's clear why this software policy (or rule) was implemented. Unscrupulous people buy the software, download it into their computer, and then return it. They get

expensive software for free. In order to stop this, the company institutes the "you open it, you own it" policy. Unfortunately — for the honest buyer — this rule appears arbitrary and unfair. This is especially true when the original salesperson said you could return it, if it wasn't what you wanted.

The "refund" employee probably wasn't aware of why the rule was put in place. His most important task was to be sure not to get into trouble by breaking store policy. He's "rule-bound." It's clear that rational discussion is not going to be productive. "The rule is the rule," and he's not going to break it.

As you can see from this example, most rules are put in place to eliminate the need for thinking and decision making. At first, this sounds bad, and sometimes, it is. However, it can be very worthwhile. If you don't have to think about something, it's easier and faster to act and behavior is consistent among all people involved. This is extremely useful and critically important in vast numbers of human endeavors.

## Behavior Control

There are two key concepts about rules: they are used to control behavior and they are used mostly in social animals. Rules govern all aspects of human behavior. When you stop at a red light, you are following a rule. If you bump into someone, you say "sorry." If there's a line for tickets, you know to go to the end.

Of course, not everyone follows the rules all the time, and these rule-breakers are punished by society. For major rule-breaking, jail is the result, but — for the large majority of rule-breakers — peer pressure is the way their behavior is altered. If you change lanes improperly while driving, you can expect a blaring horn to criticize you. If you take 15 items to the five-items-or-less checkout, you may hear comments about your ability to read.

Note that society does the punishing, but if you are not part of a social group, there is little pressure to conform. If you're stranded on a deserted island, it's unimportant if you don't cover your mouth when you sneeze. You can see that rules are a central pillar of human society. It is human nature to make and follow rules (this appears to be the source for the human concept of "fairness"). Understanding these concepts is critical to understanding and manipulating the behavior of others. That is what social interaction is all about (both professionally and personally).


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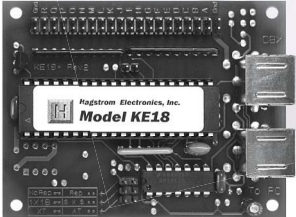


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## Overcoming Rule-Bound Behavior

There are several ways to side-step rule-bound people. The first is to find a "rule maker." In the case of returning software, the rule maker is the manager of the store, as he has the power to say yes. Talking to anyone who must only follow the rules is pointless, while talking to someone who can say yes gives you a fighting chance. You can present your case (and maybe threaten to shop somewhere else) and a decision will be based on reason rather than rules. In terms of ease and social acceptance, this "appeal to a higher power" is probably the best choice. However, if you have to go over your boss's head, you can certainly expect a negative reaction from him.

Another choice is to find a superseding rule. This takes more effort on your part and can create friction. Here's a real example: When building my rural house, I had to use a septic system because there were no sewers in the area. The inspector for our area wanted me to use 1,000 cubic yards of a special mix of dirt/fill for a leach-field. (For reference, there are about five cubic yards in a dump truck.) The cost for this fill alone was about \$15,000.00. In my view, this approach was simply absurd, but this was his rule and he was sticking with it.

Research into private septic systems found that my land was suitable for a "sand-filter" system. This only required 10 cubic yards of pea-sized gravel and cost well under \$1,000.00. This saved me lots of money and effort, but embarrassed the inspector. He nit-picked, but was unable to deny the approach.

Another option is to change the rule, but this is usually very difficult and time-consuming. The saying, "You can't fight city hall," is often associated with this approach. Quite often, the original reasons the rule was implemented are no longer known. "We've always done it this way and we aren't going to change now." As you can see, changing rules means that people have to change and very few people

like changing. If you choose this approach ... good luck. You'll need it (and probably a good lawyer, too).

## Rules and Engineering

So, how does all this relate to engineering, management, and business? Very simply, people engineer,

people manage, and people sell. Knowing about people will help you understand and predict their actions to various situations. How many times have you heard the expression "by the book"? If your boss is a "by the book" type of person, you should realize that an unconventional idea (which is not by the book) is going to be difficult for him to accept. You will have to try to

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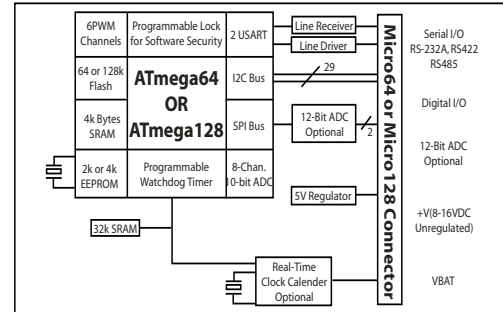
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make your idea palatable by making it appear more conventional. You will have to learn and follow his rules.

People — as a group — are generally fairly conservative. Your idea of three-piece suits made of transparent plastic is going to be a hard sell because it doesn't follow the rules that people expect. A good marketing person understands the rules that apply to

your company's customers. Different companies have different customers who have different rules. Your suit may sell well to rock stars, but I would expect that few lawyers would buy one.

Then there are those engineering rules, like "always add a 50 percent voltage margin for electrolytic capacitors." This may be okay for low voltage types where there is little difference in

price or size between 10 and 15-volt units, but what if you are operating at 225 volts? The price and size difference between a 250-volt capacitor and 350-volt capacitor can be quite significant.

Engineers design products according to sets of physical rules. These rules are taught to them in school and learned by experience. Therefore, they tend to apply rules to many things. However, as we have seen, rules are complicated, and applying them without thinking may not be appropriate.

There are situations where rules conflict with each other. The best course of action in any engineering endeavor is to think about what you are doing. Blindly following rules you learned years ago is not a good design approach. Quite simply, what if something doesn't work right? If all you know is the rule, you will never be able to understand why the rule didn't work.

## Hard and Soft Rules

Naturally, there are many classes of rules. Some are critically important (do not use an electric hair dryer while showering). Some are trivial (use only fresh batteries). Treating all the rules with the same weight is clearly not appropriate. Unfortunately, some people do just that. To them, all rules are black and white. Additionally, after an accident or other misfortune, the rule makers can overreact and create hard rules that are silly (even though their intentions are good). For example, the zero-tolerance rule for drugs and weapons in school seems like a good idea until a third grader is arrested and handcuffed for having a squirt gun or an aspirin.

The same thing often happens in business and engineering after there has been a major failure. "We must take steps to ensure that this never happens again." It is certainly a good thing to examine the failure and learn from its mistakes, but — too often — these "corrections" become hard rules while the underlying reasons for making them have been forgotten. Whole areas of research are blindly defined as off-limits because "Ted

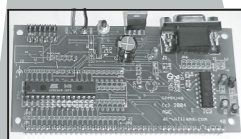
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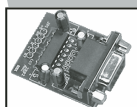
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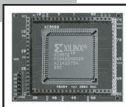
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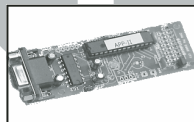
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tried that 10 years ago and it cost the company \$250,000.00."

The opposite can also occur. After a long time of successful operation, management (typically) feels that the rules can be relaxed to maximize profits or increase efficiency. They change hard rules to soft rules. Sometimes, the results are devastating. NASA administrators didn't consider the "O-ring failure at low temperature rule" important for the Challenger launch. The Chernobyl officials ignored the "don't turn off all the cooling systems" rule. Alaska Airlines felt they could save money by dismissing the maintenance rules for the rear stabilizer jackscrew on Flight 261. That flight fell from the sky because the jackscrew didn't have a few dollars worth of grease.

It isn't always easy to determine which rules are hard and soft, but the only way to do this is to understand the reasons behind the rules. You have to think. This requires effort and many people are unwilling or unable to expend this effort. The result can be strict rule-bound behavior or — as we saw above — the idea that rules don't apply to managers (or "me").

## New Ideas Break Rules

There is always a tug-of-war with rules and innovation. A new or novel idea almost always must break some rules, such as "humans weren't meant to fly." The question to ask is if the new idea breaks hard or soft rules. If the idea breaks hard rules, it will not be easily accepted. Your design for a perpetual motion machine is not likely to get off the ground, but a lot of people will listen if you have a new software algorithm that finds trig functions in half the time.

A very similar concept is the scientific rule that "exceptional claims require exceptional proof." Unless you actually build a functional perpetual motion machine (and perhaps not even then), you will not have enough proof to support your claim. However, there's a good chance that your trig algorithm can be published



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even though it's only a theory.

Radical ideas (those that break hard rules) are fun to discuss and consider, but successful radical ideas are rare. This is especially true if you need outside help to realize your idea. Few people will be willing to provide time or money on a "crazy scheme," so if you want to stay radical, you will probably have to do everything yourself.

On the other hand, you might be able to "de-radicalize" your idea by playing down the hard rule violations and emphasizing the similarities to existing rules (or research). Show that technical rules aren't violated by presenting someone else's research that supports that. Add in comparisons to existing techniques. Reduce the "revolutionary" and "unique" expressions in your text or presentation. In short, recognize that most people (especially those with power) don't like taking risks. Risks are a consequence of rule-breaking. Venture capitalists may claim that they want "new ideas," but what they probably want are new *safe* ideas. They want ideas that don't break the hard rules and have very little risk.

## When to Break Rules

There will always come a time when you will be tempted to break the rules. The key here is to fully recognize and appreciate the risks that you will take and compare them to the benefits that may result. Is it worth being expelled from college for cheating, being thrown in jail for shoplifting, or getting the nickname "Stinky" for skipping your shower?

Fundamentally, this is a cost-benefit analysis. What is the cost for breaking the rules versus the benefit for not doing so? It does seem that most people have a tough time doing this properly, as they rarely seem to think that there are any consequences for breaking the rules. Mostly they think they won't get caught.

Quite honestly, this is probably true for the first time. With this success comes a confidence to repeat the action, but — like any statistical venture — eventually the rule breaker is identified and payment is due. Many times, the cost far outweighs the benefits (being fired for sleeping



on the job, arrested for shoplifting, or sued for plagiarism). I suppose everyone has heard stories about people who ruined their personal or professional lives by breaking a rule without considering the consequences.

Sometimes, it is imperative to break rules. This is especially true with issues of personal safety. If you are driving someone to the hospital who is

bleeding profusely, it is essential that you run the red light if the intersection is clear. The risk of getting a ticket does not compare to the health and well-being of your passenger — maybe. Again, this is a decision you have to make, and you must live with the consequences of this decision, as well.

This is where breaking rules gets complicated. What if the intersection

isn't clear and you cause an accident? What about notifying the officials if your company is doing something unsafe or illegal? In cases like these, there is a dissonance between rules and this leads into the area of ethics. We can now see that ethics is really the study of conflicting rules. (We'll talk more about ethics at another time.)

## Making Rules

Managers are in a position to make rules for those they supervise, but generally, making rules is a poor management tool. You want your people to think, and making rules inhibits thinking. Furthermore, rules always seem to multiply and become more complex. Once you set a rule for one thing, you will probably need to set a rule for something related, and there are always the exceptions that also have to be dealt with.

Note that there is a difference between specifications and rules. Specifications (and the related subjects of quality and testing) define the operation of a piece of equipment. Rules govern human behavior. Specifying that certain tests must be made on a product is expected and necessary.

If you feel that rules are required, try to make them as generic as possible. If there's going to be a meeting with a major customer, say, "Dress professionally." Don't say, "Wear a suit or a dress." If a female employee wears a nice skirt, is she breaking the rule? Suppose Otto wears his sister's dress as a joke; is he breaking the rule? If someone really doesn't understand what "dress professionally" means, all you have to do is point to someone who is properly attired or say, "Look around." Enforcing rules you make can be very difficult. This is because behavior is not black or white. One person may break a rule for a very good reason, while someone else may break the same rule for no reason at all. Should the punishments be the same? If not, it appears unfair. People wonder what good rules are if they don't apply equally to everyone.

As you can see, rules are inherently

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contradictory. They specify a fixed behavior under all conditions, but the conditions are rarely the same. Identifying the conditions (refining the rules) only leads to complex situations and confusion about when to apply the rules. The IRS tax code is a classic example of this. The income tax laws take up dozens of thick volumes and are so complex and convoluted that even the government tax examiners often give incorrect information.

## Rules for Thought

For some time, people have been trying to create machines that "think." You can now buy inexpensive chess programs that play at Grandmaster levels. No one suggests that these programs think in the same way that people do, though. These programs use a brute force approach that examines every possible position for many moves in advance. People don't do that.

Somehow, people have an inherent ability to pick out a good move without a complete analysis of the chessboard. Though there is no known explanation for how this is possible, it happens nevertheless. Sometimes, people refer to this as pattern analysis, but each chess game is unique. There are no repeating patterns and very similar positions may have wildly different strengths. We have not yet been able to determine the rules by which people think and — until we do — we will not be able to program a computer with those rules. So, computers will continue to "think" in a very different manner from us.

Let's take this one step further. Most people consider that DNA — the building blocks of life — is a blueprint for the organism, but consider this: The chess rules make no mention of the physical shapes of the pieces. There are uncounted variations of chessmen. Suppose DNA only defines the rules

that the organism must follow, rather than the organism itself. After all, there are only a handful of rules to chess. The behavior and interaction of its pieces are rich, complex, and subtle. It's just a thought to consider.

## Conclusion

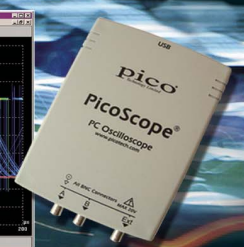
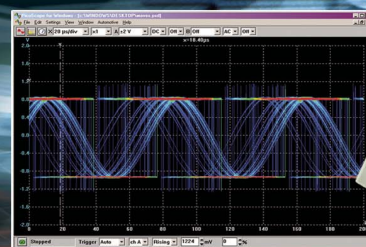
There are rules for everything, but rules have both good and bad features. Rules define behavior without consideration for context. You don't need to think or understand a rule to obey it. This makes it easy to follow rules, but this very lack of thought and understanding creates inappropriate rule-bound behavior and stifles creativity.

Understanding the principles of rules can help the engineer advance ideas, as well as interact better with others. Rules simplify and structure behavior. Because humans (and engineers) are social animals, rules project conformity and acceptance. **NV**

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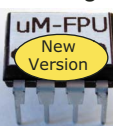
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# News Bytes

## Robotic Arm to Ensure the Safety of the Space Shuttle



In late January, workers at Florida's Kennedy Space Center installed the Orbiter Boom Sensor System — or OBSS — into Discovery's payload bay. The OBSS, which measures 50 feet in length, will attach to the Shuttle's robotic arm as one of the new safety measures for "Return to Flight." The OBSS equips the orbiter with a video camera and two laser systems to inspect the thermal protection system while in space. A breach in this system is what caused the Columbia tragedy in 2003. "Return to Flight" is the first step in the "Vision for Space Exploration," which calls for a stepping stone strategy of human and robotic missions to achieve new exploration goals.

## Are Your Sunglasses Ringing?

See the world through a pair of Motorola-enhanced Oakley sunglasses. Motorola announced a partnership with Oakley — a maker of sunglasses and other accessories — to create wearable Bluetooth-enabled communications products. In the wake of a slew of competition in the communications arena, Motorola has been making several moves of late to jazz up its image.

The deal with Oakley is just the latest venture to keep the public connected via unorthodox methods. Late last year, it teamed up with apparel maker Burton of Burlington, VT, to develop outerwear that uses interactive cell phone and portable-music technology. Additionally, in July, the cell phone company announced plans to work with Apple Computer to combine its iTunes software with Motorola's handsets. But once again, Motorola isn't alone. Other companies have also been exploring the combination of technology and apparel. The Gap, for example, recently announced a hooded sweatshirt with a built-in radio.

## Computers as a Utility

Sun Microsystems has launched a pay-as-you-go service that allows customers requiring huge computing power to rent it by the hour. At a cost of \$1.00 for an hour's worth of processing and storage power on systems maintained by Sun, the company already has interest from customers in the oil, gas, and financial services industries. So-called grid computing is the latest buzz phrase in a company, which believes that computing capacity is as important a commodity as hardware and software. The Sun Grid relies on Solaris, the operating system owned by Sun. It is not known how much the system will cost to develop, but it already has a rival in IBM, which argues that its capacity on-demand service is cheaper than that offered by Sun.

# Tech Forum

## QUESTIONS

I've been looking for USB logic analyzers and have wondered why I can't just use a USB parallel eight-bit FIFO development module. I don't have a lot of knowledge about the USB world, but I like the price of building my own if it can be done, over the \$300.00 plus models I can buy. Any ideas would be great.

**#03051** **Scott Henry**  
via Internet

I have a new computer with Windows XP. The hard drive partitions work the same as always (fdisk), but I don't know how to set up a dual-boot configuration. As usual, the help files

in Windows are useless. How do I teach the new computer to boot in either XP or 98?

**#03052** **C. Larson**  
Largo, FL

How do I test the condition of the contacts on 24 VDC 30-amp sealed relays?

**#03053** **Anonymous**  
via Internet

I have an older ATX motherboard that does not have the BIO's power-on feature — "When AC Power Restored, Boot Up Computer" — on it.

I need some type of circuit that will momentarily make contact with the power-on button when the AC

power is applied to the computer.

**#03054** **Terry Baker**  
Lindstrom, MN

I purchased a desktop telephone with caller ID from Southwestern Bell about five years ago. I have moved several times and lost the wall wart power supply, as well as the instruction manual. The phone itself only shows the polarity, not the voltage or current requirements.

The model number is CT-10. A web search only found a Pantronics wireless headset with that model number. The only other unique number was the Federal Communications Commission (FCC) registration number: 5LRCHN-32708-MT-E. I looked on the FCC website and found that this phone had been re-registered on June 3, 1999, and was made by Shenzhen Taifeng Electronic Co., Ltd., for Southwestern Bell and others. I found an address in China for this company, but they never wrote back.

Does anyone have the voltage and current requirements for the power supply for this CT-10 telephone with caller ID?

**#03055** **Ken Schmidt**  
Chardon, OH

I'm looking for a simple turn signal reminder circuit I can install in a friend's truck that doesn't have self-canceling signals. I would prefer something that could be tied into the flasher circuit. I know one of your older magazines had such a circuit, but I can't find my back issue. Any help would be appreciated.

**#03056** **Les Eckert**  
Northfield, MN

## ANSWERS

[I 1043- November 2004]

*I volunteer for a small theater that has about six small mics. I would like to build some small transmitters and a six-way receiver array in one package. Of course, all would have different frequencies*

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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All questions should relate to one or more of the following:

- 1) Circuit Design
- 2) Electronic Theory
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- 4) Other Similar Topics

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### Helpful Hints

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.



and would need to hook into a sound system. I would like it to be simple and to have a range of about 100 feet.

**#1** RadioShack has just what you need: an eight-channel microphone and receiver, \$90.00 each. That is rather pricey for six microphones and six receivers, but if your time is worth anything, it may be worth the price. You will also need a mixer to combine the signals to the audio system. You could try to put something together in the FM broadcast band using a clip-on microphone, an FM transmitter kit, and FM receiver kit for about \$60.00 per channel and a lot of labor. Check out [www.jameco.com](http://www.jameco.com) part numbers 117604CR, 211772CR, and 160979CR.

**Russell Kincaid  
Milford, NH**

**#2** Let me quickly give you my background so you can judge the value of my answer. I am the owner of a small sound, lighting, and installation company. I have many years of experience running sound, as well as installing live systems with a specialty in recording studios. Also, I design and repair electronics, and build custom “boxes” to fill needed applications.

Several concerns keep it from being simple: Any wireless mics of quality construction use “true diversity.” That is a system that uses two antennas and then switches back and forth between the two, depending on which has the best reception. This is complicated and almost critical in order to maintain proper clean and clear reception. Even then there can be problems. Where I often run sound, we have top-quality Shure mics with a transmission of less than 100 feet and we occasionally have problems.

Secondly, you would have to purchase or make the preamps to amplify the signal to go into your transmitter, which — depending on the design or your ability — could cause great degradation of the audio

signal. Also, you might need “phantom power” (depending on your mics), which is a method of powering condenser mics with 48 volts through its cable — which, in the scheme of things, is a concern, but the easiest to deal with.

In short, as well as looking for a simple answer, I assume you are also looking for quality. There is not a simple quality answer. The main concern is the audio signal quality that will be jeopardized because the signal could drop out and/or by extra noise created by the apparatus. Clarity can be difficult enough with normal equipment.

**Brandon Spivey  
Nashville, TN**

## [I 1045 - November 2004]

*I'm trying to repair an RCA 25-inch TV, manufactured in April of 2002. It is model #F25442, chassis #CTC-203A09. The TV is completely dead and will not make a sound. The fuse is fine (never shorted), B-voltage is present, and the flyback, horizontal driver, powerline regulator, resistors, and caps appear to be okay. Any answers would be appreciated.*

**#1** The problem is likely in the RF section because there is no sound or picture. Use your 50-MHz or better scope to check the signal at the IF input. If there is no signal, check the local oscillator bias. If that is okay, check the voltages on the RF and mixer transistors. A visual check of the PC board for bad solder and cracks in the copper runs may be helpful. If there is signal at the IF input, follow the signal down to the detector. When you find the stage with no signal, check the transistor or IC and all of the capacitors in the circuit. This will find the problem 99% of the time.

**Russell Kincaid  
Milford, NH**

**#2** To begin with, I hope that you have experience in TV servicing because some of the voltages

present could prove fatal. That being said, there are a number of symptoms that could cause the “dead set” problem. The list is too lengthy for this column. Check R14124, the 3.3-ohm, two-watt feed to the 15.5-volt supply. Check the drive signal to the base of Q14401 HOT. If it's absent, check the resistance of the horizontal drive transformer T14301. You may have to remove T14301 and resolder the transformer leads onto the posts.

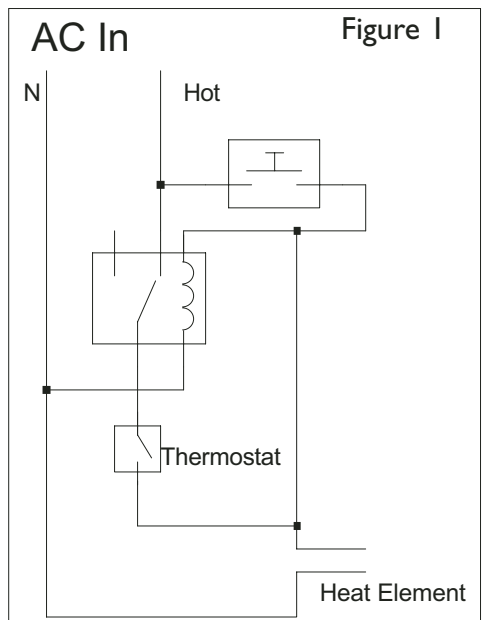
**Eric Schmidt,  
Glendale, NY**

## [I 1046 - November 2004]

*I have a small, 110 VAC, 1,500 W hot water tank heater in a seldom-used bathroom. I would like to add a push-button control to turn it on only until its thermostat kicks off. Ideas?*

This should be a really easy thing to do, though let me add that I have not built this. I have designed a simple circuit (Figure 1) that will just let the water heater turn itself off by the use of its own thermostat.

Hook up a relay switch to the input power with the coil connected to the hot wire of the post thermostat. Then add a momentary switch across the un-switched power and to the relay coil's hot side. Note that if there



is any delay with the thermostat turning on, the momentary switch used to energize the coil is also powering the heating element, so make sure it can handle the current. When the button is pushed, it should activate the whole system. When the thermostat turns the heater off, it will disengage the relay and turn everything back off. A little extra you might want to add is a visual indicator light that would confirm that the element has stayed on after the release of the switch.

**Brandon Spivey**  
Nashville, TN

[12045 - December 2004]

*I am looking for a simple circuit to amplify or intensify the ring current on a phone line. I want to ring more than four phones at once on a single line. The current supplied by the phone company is not adequate to ring more than two. Is there a simple circuit to increase the ring current without reflecting back on the phone company's lines?*

**Charlie Wineman**  
via Internet

**#1** Take a look at the commercially available unit — Model RG-10A, made by Viking Electronics. The need to ring more than three or four phones is a common problem in commercial telephone installations. I researched the issue and considered designing and building my own unit. There are many points to consider, such as ring cadence, passing caller ID, FCC and telephone company registration, etc. I decided that the nominal cost of the RG-10A was far outweighed by the ease of installation.

**Bob Hill**  
Burbank, CA

**#2** If the telephone company cannot supply enough ringing current for more than two telephones, it is a simple matter to construct a ringing signal generator and use that to ring the desired phones. An excellent ringer generator design brief by Jim

Crandell appeared in the May 10, 2004, issue of *Electronic Design Magazine*. It consists of an audio amplifier chip hooked up as a 20-Hz phase-shift oscillator. The output of the chip drives a common step-up transformer to produce the 90-volt, 20-Hz sine wave that is needed by the phone ringer.

By rectifying the incoming ring signal and interfacing the DC produced to the generator, it will operate only when the incoming ringing signal is present on the phone line. The schematic diagram for the generator can be obtained by visiting [www.elecdesign.com/FILES/29/7878/figure\\_01.gif](http://www.elecdesign.com/FILES/29/7878/figure_01.gif).

**Anthony Caristi**  
Waldwick, NJ

**#3** I've been a maintenance technician for several years at a phone company and your question concerns me. The phone company sends you about 90 VAC ringing voltage. Experimenting with the phone line at this voltage could harm you or an unlucky tech who happens to be working on the cable at that time. The ringing current already being sent to you should easily ring six quality phones. Your problem may

be poor loop design, a fault on the pair, or a defective phone. Maybe you live more than 10 miles from the central office. I suggest you call the local phone company and have your line checked. Ask about your loop length and/or any devices on your line, such as pair gain systems. If you have a long loop, you may need a TRE (Transmit/Receive Equipment) installed on your line. This device — installed at the central office or remote — will amplify line current and ringing for you.

**John Johnson**  
Keyser, WV

[12041 - December 2004]

*I have a small sports car and want to install an amplifier for the subwoofer. Unfortunately, none of the commercially available units is small enough to fit in the available space. Since I don't need all that much power, can you suggest a fairly compact design?*

**Tom Smith**  
via Internet

**#1** You want to look for a Class D amplifier. Class D uses switches to obtain high efficiency and small size. I have not found any consumer kits,

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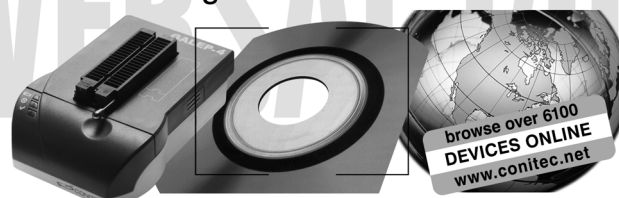


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Circle #76 on the Reader Service Card.



but check out the Fairchild LM4651 and Philips TDA8926 or TDA8929.

**Russ Kincaid**  
Milford, NH

**#2** Try using a "computer audio" subwoofer or just the amplifier from one, if that's all you need. Many of them are compact compared to home units, and the amp often runs on 12 volts. The cheapest source is probably eBay or a local thrift store.

**Dean Carpenter**  
via Internet

**#3** I think you need a simple amplifier circuit. I have a circuit (Figure 2) which can deliver up to 10 W of power. For example, >eight W RMS/channel, two ohm; >six W RMS/channel, four ohm at a supply voltage of 16 V; and also >four W RMS /channel, four ohm at 12 V supply.

**Sibi George**  
Kerala India

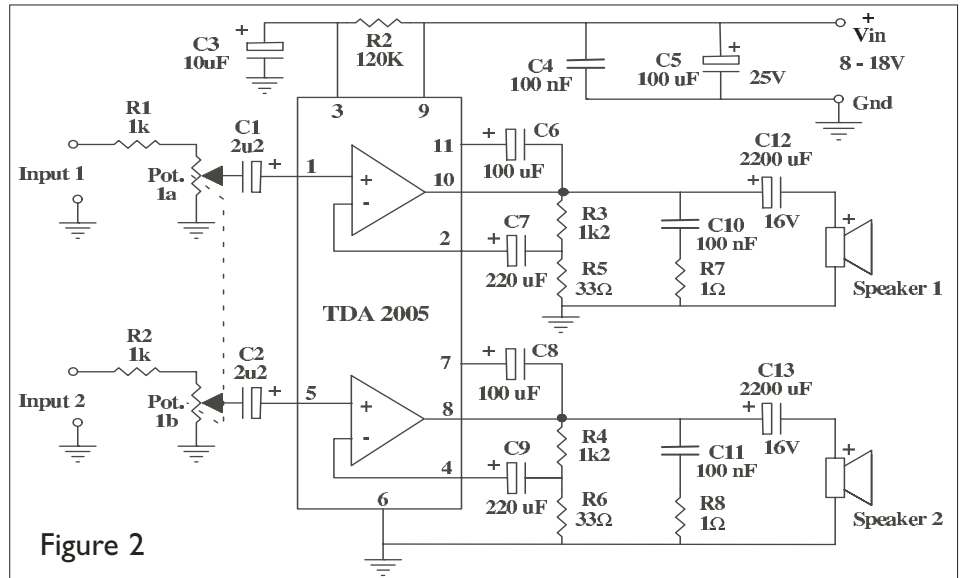


Figure 2

## [12048 - December 2004]

*I run a five-hp, single-phase air compressor in my shop due to the fact that I have to synthesize my own three-phase current. On the advice of a repairman, I had an*

*electronic module installed on the motor to replace the starting contacts, which were burning out every six months or so. Since then, I've had to replace the module at least twice, which involves removing the motor from the compressor and taking it to a service facility 50 miles away. This costs me about \$300.00, as well as several days of a near shut-down condition. What is this expensive*

*module, and can I replace it myself? If so, where can I get one? Should I just go back to conventional contacts and replace those every six months?*

**Fred Howe**  
Owego, NY

Usually, it seems that magnetic starters and even relay contacts are more reliable than what you seem to be seeing. I would think that contacts could benefit from a surge suppressor-type device (metal-oxide varistor, MOV) across the contacts to quench the arcing a bit and lengthen the life of the contacts. Also, have you checked the line voltage? It may be high, which increases the arcing and stress at startup. Are there other pieces of equipment that might be producing arcing on the line to the compressor? Maybe some line filtering and suppression on the input would be helpful if an external source is stressing the components. In high lightning rural areas, there are large MOV devices that connect to the line input at the breaker panel to keep lightning surges from blowing stuff up. If the compressor is at the end of a long run, the inductive effect of the long line could be part of the problem; industrial-strength surge protection might do the trick.

**Dean Carpenter**  
via Internet

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**Digital Storage Oscilloscope Module**

PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

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with Large LCD Displays  
Output: 0-30VDC x 2 @ 3 AMPS & 1ea. fixed output @ 5VDC@3A  
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Ripple Coefficient:  $< 250uV$   
Stepped Current: 30mA +/- 1mA  
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- Ceramic heating element for more accurate temp control
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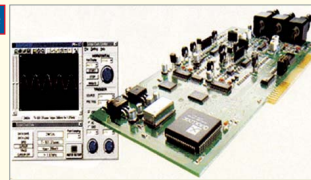
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\*Both Models have a 1A/5VDC Fixed Output on the rear panel\*

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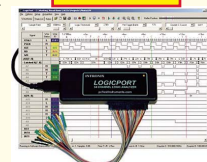
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- Day & Night Auto Switch
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- Image Sensor: 1/4" SONY Super HAD CCD
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Built-in Lens: 4.3mm
- S/N Ratio: > 48dB (AGC OFF)
- Min. Illumination: 0Lux

**1-4:\$89.00 5+:\$79.00**

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